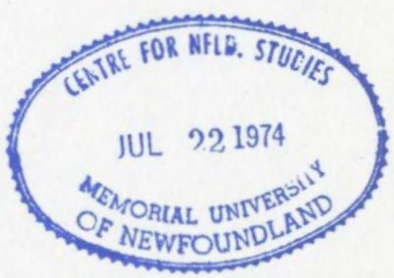
ONTOGENCY OF NESTING HABITAT RECOGNITION AND PREFERENCE IN NEONATAL HERRING GULL CHICKS, **LARUS ARGENTATUS** PONTOPPIDAN

CATHRYN M. NOSEWORTHY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Abstract

This investigation was designed to examine the development of nesting habitat recognition and preferences as a function of habitat and social stimuli in neonatal Herring Gull chicks. The initial experiment studied the daily development of nest site preference during the first week post-hatch and thereafter weekly development until fledging. The test procedure, which was essentially the same for all experiments, consisted of relocating chicks 20 m. from the nest and observing their movements. During these observations, latency, time moving, initial orientation, final distance from the nest, and initial and final vegetation characteristics were recorded. Results indicate that Herring Gull chicks exhibit a preference for the nest site area during the first week post-hatch and this preference wanes after the first week until fledging. Chicks of all ages showed a preference for vegetation similar to that of the nest site area. Nest site preferences are ecotypically controlled since foster-reared chicks exhibited the same preference for their foster nests as did normal-reared chicks for their natural nests.

Several experiments examined the effect of vegetation characteristics and social stimuli provided by other chicks on nest site attachment and recognition. Vegetation type and the presence of siblings were found to be important stimulus properties of the nest situation in nest area

attachment. Chicks exhibited a preference for vegetation similar to that at the nest site and for siblings over non-siblings. Nest site recognition appeared to be predominantly a visual response, at least in visually experienced animals. Vegetation characteristics, landmarks and the presence of other chicks were found to be among the cues used to recognize the nest site. The results of these experiments were interpreted as supporting the hypotheses that nesting habitat preferences are evident in Herring Gulls during the prefledging period and that habitat and social stimuli are important in the development of nest site preferences and recognition. These neonatal habitat preferences may be influential in determining later preferences for nesting sites and may be responsible for the observed stereotypy in adult habitat preferences.

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Introduction to the Problem

Species preferences for particular nesting habitats are well documented (Elton, 1930; Lack, 1933; 1937; 1954; Moreau, 1935; Lack & Venables, 1939; Miller, 1942; Kendeigh, 1945; Thorpe, 1945; Snyder, 1948; Collias, 1951; Tinbergen, 1953; Hinde, 1959; Emlen, 1963; Hilden, 1965; Klopfer & Hailman, 1965; Beer, 1966; and Klopfer, 1969), as is the tendency of individuals of many avian species to return to similar habitats and frequently to the same nesting area or territory for breeding in successive years (Stoddard, 1931; Boyd & Landsborough, 1937; Emlen, 1938; 1940; 1963; Gross, 1940; Kendeigh, 1941; Ruiter, 1941; Stoner & Stoner, 1941; Lack, 1943; Nice, 1943; Farner, 1945; Miller, 1947; Austin, 1949; Von Haartman, 1949; Richdale, 1951; Kluijver, 1951; Tinbergen, 1953; Beer, 1966; LeResche & Sladen, 1970; and Bongiorno, 1970). Similar phenomena have also been reported in salmon (Hasler, 1956; 1960) and insects (Rau, 1934; Thorpe, 1944).

Some evidence indicates that such marked habitat preferences are firmly established in young animals. Klopfer (1963; 1965) tested foliage preferences in young Chipping Sparrows, Spizella passerina passerina Bechstein, and found that the typical species-preferred foliage was chosen by young. Wecker (1963) reported that laboratory-reared Prairie Deer Mice, Peromyscus maniculatus bairdi Hoy & Kennicott, derived from wild field stock chose the typical species-preferred habitat of the field over a woods habitat. It

has also been demonstrated that laboratory-reared Prairie and Woodland Deer Mice, Peromyscus maniculatus gracilis Le Conte, in a choice test in the laboratory, prefer artificial habitats most closely resembling the natural habitat of their species (Harris, 1952), even though they could fully tolerate other habitats (Dice, 1922). Fabricius (1951) tested several species of hand-raised ducklings in an open field test and found that young preferred the typical adult habitat.

Goethe (1937) demonstrated an attachment to the nest site in Herring Gull chicks. Chicks were found to return to their own nest site after being transported 18-63 meters from the nest. Noseworthy, Lien & Stoker (1973) found that Herring Gull chicks under three weeks of age returned to the nest site, while older chicks did not return to the nest territory but relocated in vegetation similar to their collection point. Ring-billed Gull chicks, Larus delawarensis Ord, also, have been found to prefer a familiar to a novel rearing area in the laboratory, although this preference was not significant at 4-5 days post-hatch (Evans, 1970a). Hess (1959) exposed domestic chicks to a patterned environment at different times during the first several days after hatching and found a preference only on Day 2 post-hatch. It also appears that chicks know the nest territory in detail (Tinbergen, Brockhuysen, Feekes, Houghton, Kruuk & Szule, 1962) since chicks of several species have been observed, during alarm or disturbance, to repeatedly seek out familiar

shelters in neighboring vegetation to the nest site (Strong, 1914; Goethe, 1937; Kirkman, 1937; Tinbergen, 1953; Moynihan, 1959; Beer, 1966; Evans, 1970a). Furthermore, Evans (1970a) experimentally demonstrated that this repeated selection of the same hiding place depends on a learned preference. Young Ring-billed Gull chicks learned the discriminations and motor patterns necessary to move repeatedly to a specific location in a test pen (Evans, 1970a). Attachment to the rearing habitat, then, is apparent during the first few weeks of life, although the precise chronological development has not been established for any of the above species.

How such rearing area preferences are established during ontogeny is also speculative. Several authors (Thorpe, 1944; 1945; Miller, 1942; Collias, 1951; and Hilden, 1965) have suggested that habitat preferences are established through environmental imprinting, a rapid, stereotyped exposure learning similar to social imprinting. Data reported by Drost (1958) provides support for this hypothesis. He transferred 1000 young Herring Gulls from a sea coast to inland zoological gardens for rearing. It was found that many of these gulls, when adults, returned to the rearing place, or to similar areas in different localities, for nesting. Indirect evidence comes from Hess' (1959) data on preferences for a patterned environment and the demonstration of imprinting to stationary objects (Hess, 1959; Gray, 1960; and Bateson, 1966). Additionally, there is evidence that domestic chicks prefer familiar over unfamiliar

conspicuous static objects (Bateson, 1964a) and that conspicuous visual stimuli can act as reinforcers (Bateson & Reese, 1969; Evans, 1972). Evans (1970a) has also shown that the visual characteristics of rearing pens are learned by Ring-billed Gull chicks.

Other authors have attributed habitat preferences to an innate mechanism of the species (Lack, 1933; 1954; Svardson, 1949). Studies in which reciprocal transfer of gull eggs have been made, however, indicate ecotypic control of such behaviours. Emlen (1963) found that Herring Gull chicks raised on cliff ledges or vegetated plateaus responded differentially in escape behaviour. Cliff-reared chicks remained motionless on an elevated test platform while plateau-reared chicks exhibited escape locomotion. Cross-fostering of eggs from these two groups showed that chicks responded appropriately in escape tests according to the rearing habitat. Smith (1966), studying escape behaviour of three gull species differentially adapted to cliff nesting, also found that chicks' escape responses varied according to the rearing habitat. Although foster chicks were not tested for preferences for the foster rearing areas, the fact that they remained at the foster nests indicates that such preferences were developed. Finally, Schuz (1938; 1940) transferred Short-billed Gull, Larus canus Linnaeus, eggs to Black-headed Gull, Larus ridibundus Linnaeus, nests for incubation and found that, when adult, some of these birds returned to their foster rearing place for nesting.

Social stimulation has been suggested to be an important factor in establishing habitat preferences (Klopfer & Hailman, 1965). Individuals may be attracted to a particular area because of an attraction to familiar animals rather than an intrinsic preference for the area, so that each generation adopts the preferences of the parent generation. Preferences for conspecifics have been demonstrated in several avian species (Howells & Vine, 1940; Kilham, Klopfer & Oelke, 1968; Gottlieb, 1965), even in the absence of prior food reinforcement during social feeding (Evans, 1970a). As well, social stimulation has been reported to enhance the formation of early spring 'club' aggregations (Tinbergen, 1953) and the selection of feeding areas in adult gulls (Frings, Frings, Cox & Peissner, 1955). Food and social preferences passed from one generation to another have also been documented in mammals, such as the Black-tailed Prairie Dogs, Cnyomys ludovicianus ludovicianus Ord, (King, 1955), Japanese Macaques, Macaca fuscata Lacepede, (Miyadi, 1959) and in some birds (Fisher & Hinde, 1950). Moreover, evidence indicates that attractiveness of the colony is an important factor in habitat selection by Herring Gulls nesting for the first time (Drost, 1958). It is likely, therefore, that social stimulation is an important factor in establishing habitat preferences, particularly in Herring Gulls, whose colonial nesting habits and average clutch size of three result in continuous social stimulation.

One difficulty with any hypothesis of the development of habitat preferences is the lack of information on the factors involved in habitat recognition. It is possible, for instance, that habitats that appear very different to the observer may in fact contain the cues relevant to the organism, so that it is necessary to consider the organism's 'umvelt' (Von Uxuell, 1921) or perceived environment in studying habitat preferences. Klopfer (1963; 1965; 1967), in a series of experiments to determine the foliage perch site preferences in sparrows, found that for the White-throated Sparrow, Zonotrichia albicollis Gmelin, the light intensity and distribution of shadow patches were the relevant cues for distinguishing perch sites, while for the Chipping Sparrow the relevant cues appeared to be foliage size, shape and density. The fact that different vegetation stimuli were important to these two species make it apparent that generalizations across species, even closely related ones, cannot validly be made. The heavy reliance of birds on the visual modality would indicate that, although other sensory capacities may be used, vision would be of primary importance in nest site attachment and recognition. Evidence supports this supposition. Lack (1933; 1954), Lack & Venables (1939) and Wasilewski (1961) have suggested that the relevant features by which avians distinguish habitats are of a 'gestalt' nature and involve the visually prominent, conspicuous features of the habitat, such as the vegetation.

Vegetation characteristics, such as the height, spacing and species, have also been correlated with habitat preferences (Pitelka, 1941; Kendeigh, 1945; Guillon, 1960). Moreover, Bongiorno (1970), in an experimental study of nest site selection by adult Laughing Gulls, Larus atricilla Linnaeus, demonstrated that changing the vegetation topography of the habitat by mowing resulted in decreased probability of nesting. He concluded that vegetation characteristics were important habitat features used by these gulls in nest site selection. Adult gulls also appear to have a detailed knowledge of the nest area using visually prominent habitat features. Baerends, Drent, Glas & Groenewold (1970) found that adult Herring Gulls return to the nest site, even when eggs and young are displaced some distance away, and that they prefer an empty, strange nest on the nest site to their own nest and eggs displaced 75 cm.

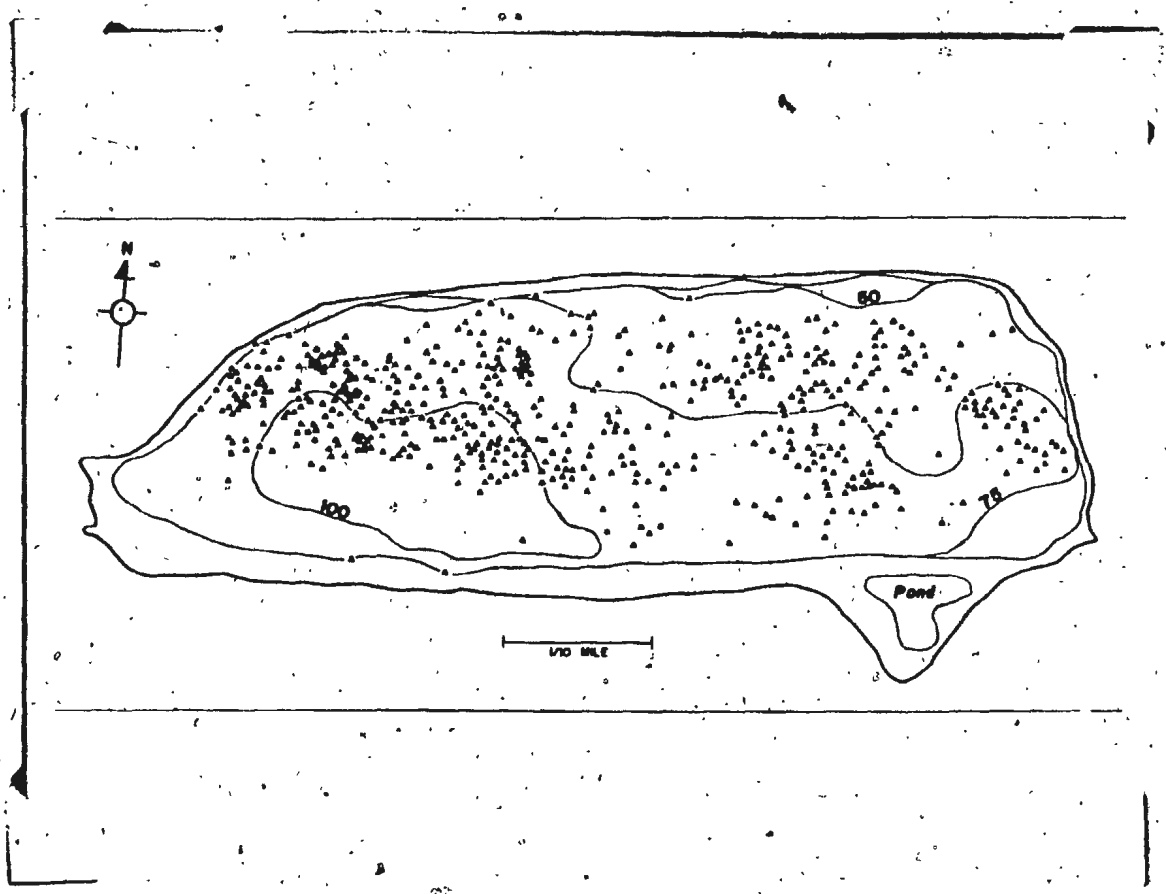
Landmarks have been shown to be among the cues used to locate the nest site. Tinbergen (1953) demonstrated that displacement of a visually prominent landmark correspondingly disoriented the Herring Gull from its nest, although only temporarily. Furthermore, Baerends et al (1970) reported that acceptance of a displaced nest was facilitated by a corresponding displacement of a conspicuous landmark. Other nest site stimuli to which birds respond are not known.

However, very little is known concerning recognition cues in young and how they develop. There is observational evidence that neonatal Herring Gull chicks discriminate between vegetation types and use vegetation characteristics as cues in nest site recognition (Noseworthy et al, 1973). It would appear then that cues which should be of primary importance in the development of nest site attachment and recognition in gulls are those related to the habitat, such as vegetation, landmarks, etc. and social stimulation. The present series of experiments were designed to assess the role of selected aspects of habitat and social factors in the development of nesting habitat recognition and preference in neonatal Herring Gull chicks.

The Study Site

Little Bell Island, measuring 1500 meters by 400 meters, located in Conception Bay, Newfoundland, was chosen as the study site (see Figs. 1 and 2). In the spring-summer of 1972, Little Bell Island had an observed breeding population of 876 pairs of Herring Gulls, Larus argentatus Pontoppidan. Other avian species breeding on the island in small numbers included Common Starlings, Sturnis vulgaris Linnaeus, Savannah Sparrows, Passerculus sandwichensis Gmelin, Great Black-backed Gulls, Larus marinus Linnaeus, Ring-billed Gulls, Larus delawarensis Ord, and Black Guillemots, Cepphus grylle Linnaeus. The latter two were not present in 1971. No mammals were observed on the island.

FIG. 1. The Study Site, Little Bell Island, Conception Bay, Newfoundland



Δ- HERRING GULL NEST

FIG. 2. The Study Site, Little Bell Island, Conception Bay, Newfoundland.

The vegetation of the island may be divided into distinct areas of grassland, marshland, shrub and herb areas, as well as areas of mixed vegetation. The predominant vegetation types in which Herring Gull nests occurred were: 39.0% in grassland, 30.0% in shrubs, 30.3% in herb areas and .7% in moss areas (see Table 26, Appendix).

Pilot Data

Preliminary investigations were carried out to: 1) obtain a detailed description of the nesting microhabitat of the Herring Gull population under study; 2) determine whether young Herring Gull chicks of this population exhibited a preference for the nest site area; and 3) determine whether this behaviour varied with age.

In the spring of 1971 and 1972, Little Bell Island was surveyed into 50 meter quadrats and the number and the location of each nest in each quadrat recorded. Seven variables were recorded for each nest including: clutch size, nest exposure, nest level, predominant vegetation of the nest site, predominant vegetation of the surrounding area, basic nest material and distance from the nearest nest. Nest exposure was judged by the experimenter on a three point scale of exposed, moderately hidden and well hidden (see Noseworthy et al, 1973 for pictures defining this scale).

Data were analysed using means, frequency distributions and a correlation matrix of all variables. Only the 1972 data will be discussed here since the 1971 data have

been presented elsewhere (Noseworthy et al, 1973). The total number of Herring Gull nests recorded on the island was 876, an increase of 314 over the 1971 total. The majority (44.2%) of nests contained 3-egg clutches, 26.9% contained 2-egg clutches, 28.8% contained 1-egg clutches, while only one (.1%) nest contained 4 eggs. The majority of nests (56.8%) were in the open, 35.7% were partly hidden, while only 7.5% were well hidden. Almost precisely the same percentages were recorded in 1971 (57%, 36%, and 7%, respectively). Tinbergen (1953) noted that Herring Gulls prefer open areas except for nesting, when sites near plants or bushes are selected. The low proportion of nests in cover in this study, however, indicates that Herring Gulls of the Little Bell Island population prefer open areas for nesting, especially since approximately one-third of the island would provide ample cover.

Nests at ground level accounted for 76.9% of the total while 23.1% were on hummocks. Most nests (69.3%) were built in low-lying vegetation (grass, 39.0%; herbs, 30.3%), 30.0% were in shrubs, while only .7% were found in moss. Vegetation surrounding the nest site was again predominantly grass and herbs (39.0%, 30.5%, respectively), 27.3% was shrubs and .1% was moss.

The majority of nests (64.3%) had grass as the basic nest material, 34.6% had moss, while herbs were found in only 1.1% of the nests. It appears, therefore, that Herring Gulls do not necessarily utilize the most available materials

for nest construction. Moreover, no relationship was found between nest site vegetation and the basic nest material (rho=.02, P.<.42). Similar observations have been made by Beer (1966) who reported that Black-headed Gulls may collect nest material from .15 m. to 450 m. from the nest.

The average distance between nests was 7.3 m. Some 40% were 5 m. from the nearest nest, 15.3% were only 3 m. away, while 2.8% were more than 20 m. from the nearest nest. Nests tended to be farther apart in covered areas and closer together in the open (r_{xy}=.07, P.<.04). Ground nests tended to be closer together than hummock nests (r_{xy}=.07, P.<.05). These relations may reflect the preference for low-lying vegetation areas for nesting or may be a response to aerial predation since Little Bell Island has no ground predators.

To examine whether Herring Gull chicks of the Little Bell Island population exhibited a preference for the nest site area, a total of 31 chicks, 1-5 weeks old, were captured from grass, herb and shrub sites in the nest colony in the summer of 1971. Once a chick was captured, it was placed in a cardboard box with no cover and transported 30-50 m. to a different vegetation type and released. The experimenter withdrew approximately 50 m. and observed the chick through binoculars. The following measures were recorded: final location of chick, vegetation type at the collection point and at the final resting location, and vegetation density. Density was judged by the experimenter on a three point scale, sparce, moderately dense, and dense. Locomotion was observed

until the chick remained in one location for 10 minutes.

Results indicated that a significant number of chicks returned to the same territory (within 1 m. of the nest) or to a vegetation area similar to the one in which they had been captured (chi=8.53, P.<.02, see Table 1). This relocation in the original vegetation was significant for all vegetation types and did not vary with the type of vegetation in the capture or release area. Additionally, the choice of relocation vegetation seemed relatively unrelated to the amount of cover afforded by the vegetation, since chicks were observed to relocate in less dense vegetation of the original capture site type in preference to denser, different vegetation nearby.

Table 1

Percentage of Chicks by Age Returning to Capture Territory, Same Vegetation, or Different Vegetation

Age	N	Capture Territory	Same Vegetation	Total Returning to Same Vegetation	Different Vegetation
1-3 Weeks	17	39.9	49.0	88.9	11.1
3-5 Weeks	14	0.0	84.7	84.7	15.3

Comparisons between young chicks 1-3 weeks of age with older chicks, 3-5 weeks of age, showed no significant

difference between the two groups, as most birds in all ages returned to the original vegetation type. However, a significant difference between younger and older chicks was found in the tendency to return to the capture territory ($chi=7.00$, $P.<.01$). The younger chicks most frequently returned to the original capture territory, usually the nest, while older birds returned to similar vegetation but did not relocate in the capture area (Table 1).

It appears, therefore, that some Herring Gull chicks do exhibit an attachment to the nest territory and that this behaviour wanes with age. How and when the attachment to the nest site area develops and how the nest site is relocated requires investigation. Moreover, how the apparent vegetation preferences of older chicks are established is speculative. These problems were examined in six experiments. The first experiment studied the development of nest site attachment per se from hatching to fledging. The second experiment assessed the effects of visual deprivation on nest site attachment and recognition. The third experiment examined the role of stimulus "conspicuousness" and landmarks in nest site recognition. Experiment 4 attempted to demonstrate individual recognition among chicks. Experiment 5 studied the use of social stimuli in nest site attachment and recognition. Finally, Experiment 6 examined the effects of social rearing and testing on nest site attachment and recognition.

Experiment 1. The Development of Nest Site Attachment

The pilot data collected indicated that Herring Gull chicks under three weeks of age exhibit an attachment to the nest territory. However, the post-natal development of this attachment is not known. It has been observed that during the first week post-hatch gull chicks have a well developed locomotor ability but are nearly totally dependent on parental care for survival (Evans, 1970a). During this period parents do not recognize individual chicks but rather find their own young by location, with feeding and brooding, etc., restricted to a specific nest site territory. It is adaptive, therefore, that chicks have an attachment to the nest site and that excursions from this area be held to a minimum during the first week of life. Attachment to the nest territory was, therefore, hypothesized to be an important mechanism controlling locomotion and ensuring adequate parental care during the first week. After this time, the onset of individual recognition by parents and young aids maintenance of family unity. It was expected that an attachment to the nest site area would be found in daily tests during the first week post-hatch and that a decreasing preference would be evident in weekly tests after this time until fledging.

Method

Subjects

A sample of 84 Herring Gull chicks was randomly selected from the nests located on the west half of Little

Bell Island. One-half of the island was selected for feasibility purposes, since the study site had to be traversed and nests checked several times daily. Chicks were chosen from three-egg clutches and were individually marked after hatching so that age could be accurately determined when chicks were recaptured. The location of the nest site, as well as the type, height and density of the surrounding vegetation, was recorded on a grid map of the island. Density of vegetation was rated by the experimenter on a three point scale, 1-sparce, 2-moderately dense, and 3-dense. Chicks were then assigned randomly to one of seven groups for testing on days 1-7 post-hatch.

Procedure

When a chick achieved testing age, its nest was located, the chick found and removed from the nest site. It was then placed in a wooden carrying box with a transparent cover (30 cm. x 30 cm. x 30 cm., see Fig. 3). The chick was then transported 20 m. in a random direction (previously determined by a random series of North, South, East and West) and released. Clutch siblings were left in the nest or nest area undisturbed. The following measures were recorded: latency (in seconds), time moving (in seconds), initial orientation (in degrees deviance from a straight line of the chick to the nest as judged by the experimenter), final distance from the nest (in meters), number of returns (less than 10 m. from the nest), and the type, height and density

FIG. 3. Wooden Carrying Box Used in All Experiments to Relocate Chicks

of the vegetation at the final resting location. Testing was terminated when the chick was within one meter of the nest site or had been immobile for 10 minutes. All chicks were returned to the collection point after testing.

To determine whether attachment to the nest site was ecotypically controlled, 12 additional eggs were selected using the same selection and recording procedures described previously. These eggs were then reciprocally transferred to foster nests so that the vegetation type at the foster nest was different from that of the natural nest. Hatching occurred between 5-10 days after transfer. Chicks were reared in the foster nests until testing on Day 6 post-hatch, using identical test procedures as were previously described. Day 6 post-hatch was chosen as the testing age since initial testing indicated it was the first day on which a preference was exhibited.

Temperature, wind speed and precipitation were recorded to provide a check on the similarity of test conditions between groups. These measures were also intercorrelated with the previously described dependent measures to determine if there was any relationship between chick behaviour and these environmental conditions.

Relocation of all test chicks (both first week and foster-reared chicks) at weekly intervals until 5 weeks of age was attempted to determine whether excursions from the nest site area were restricted to areas similar to the nest site and whether any age changes in area preferences were

evident. Test chicks were located by experimenter and assistant thoroughly searching the nest territories, and if they were not found, a surrounding 50 m^2 area was searched. The first chick tested weekly was randomly chosen to ensure that chicks were not being tested at the same times in each testing session. Once a chick was found, it was placed in the wooden carrying box and transported 20 m. from its collection point. It was then released in a vegetation type that was different from that of the collection point. The same measures were recorded as for daily-tested chicks as well as initial distance from the nest (in meters) and the type, height and density of the vegetation at the collection point. The testing procedure was then identical to that described for daily-tested chicks.

Results

Data are reported in the following order: first, data for daily-tested chicks will be given, then the results for foster-reared chicks, weekly-tested chicks, and finally the correlational data on environmental conditions and the dependent measures.

Daily-tested chicks

The means and standard deviations of all dependent measures for daily-tested chicks are presented in Table 2.

Latency. The variance of latency within subjects was high for all experiments and the variance was not homogeneous. The F max test for homogeneity of variance of

Table 2

Means and Standard Deviations of Response Speed, Time Moving, Initial Orientation, and Final Distance from Nest of Chicks During the First Week Post-hatch

Age Post-hatch (in days)	N	Response Speed (latency in seconds)	Time Moving (in seconds)	Orientation (in degrees)	Final Distance From Nest (in meters)
1	12	$\bar{X}$ = .18	15.92	22.50	15.25
		S.D. = .38	33.58	55.94	2.73
2	12	$\bar{X}$ = .40	14.67	7.50	18.75
		S.D. = .46	22.26	25.98	1.42
3	12	$\bar{X}$ = .72	59.58	7.50	16.92
		S.D. = .42	133.59	25.98	9.82
4	12	$\bar{X}$ = .73	89.58	26.25	13.67
		S.D. = .40	71.49	40.52	5.45
5	12	$\bar{X}$ = 1.00	116.17	33.75	16.67
		S.D. = 0.00	137.46	43.44	12.20
6	12	$\bar{X}$ = .76	83.58	18.75	11.08
		S.D. = .44	72.31	30.09	6.05
7	12	$\bar{X}$ = .85	108.17	19.58	11.00
		S.D. = .34	59.23	22.61	10.80

latency for daily-tested chicks yielded an F max=30.01 ($P.<.01$). In order to reduce the variability, response speed, the reciprocal of latency was calculated and is discussed throughout the text (see Tables 27 and 28, Appendix, for raw data summaries). A significant difference in response speed between chicks of different ages was found ($F=6.51$, $P.<.001$). A summary of this analysis is presented in Table 3. Individual comparisons (t tests, Winer, 1971) indicated that Day 1 and 2 chicks had significantly lower response speeds than all other age groups ($\bar{X}=.18, .40$, compared to .72, .73, 1.0, .76, and .85, respectively; $t=4.39$, $P.<.03$). No other age groups differed from each other, although a trend of increasingly higher response speeds with increasing age was evident.

Table 3

Summary of Analysis of Variance of Transformed Latency (Response Speed) of Chicks Tested during the First Week Post-hatch

Source	df	SS	MS	F	P
Age	6	5.6554	.9426	6.5042	<.001
Error	77	11.1586	.1449		

Time Moving. An F max test for homogeneity of variance of time moving was significant (F max=32.62, $P.<.01$). A log transformation of time moving was done and both raw and transformed data analysed. Since analysis of variance

produced the same significant differences on raw and transformed data (see Tables 27 and 29 for transformed data summaries), the raw data will be discussed here. A significant difference among groups was found on time moving ($F=2.90$, $P.<.01$). A summary of this analysis is presented in Table 4. Individual comparisons (Studentized Range Statistic) showed that Day 1 and 2 chicks spent significantly less time moving than all other age groups ($\bar{X}=15.92$, 14.67 sec. as compared to $\bar{X}=59.58$, 89.58, 116.17, 83.58 and 108.17 sec. respectively; $F=4.03$, $P.<.04$). No other age groups differed significantly from each other although as with response speed, a trend of increased time moving with greater age was evident.

Table 4

Summary of Analysis of Variance of Time Moving during the First Week Post-hatch

Source	df	SS	MS	F	P
Age	6	123007	20501.1	2.8999	.010
Error	77	544366	7069.7		

Orientation. An F max test for homogeneity of variance of orientation was not significant (F max=7.47, P.>.05). Analysis of variance of orientation was not significant (F=.81, P.>.05). The mean degrees deviance of orientation to the nest was 19.4.

Distance. An F max test of homogeneity of variance of distance from the nest was significant (F max=13.96, P.<.05). A log transformation was performed on distance. No significant differences were found in analysis of variance of either raw or transformed data (F=1.59, P.>.05; F=1.46, P.>.05, respectively). The mean distance from the nest was 14.8 m.

Number returns. Subjects were divided into those returning within at least 10 m. of the nest and the number not reaching this criterion (see Table 5). It was evident from this division that the number of chicks reaching the criterion increased with greater age. A chi square test showed that the number of chicks reaching criterion was significantly greater than expected by chance on Day 6 and 7 (chi=6.36, P.<.03; chi=15.12, P.<.001, respectively) and significantly less than expected on Day 1 and 2 (chi= 5.06, P.<.03; chi=8.60, P.<.001).

Table 5

Number of Chicks Achieving Nest Return Criterion during the First Week Post-hatch

	Days Post-hatch						
	1	2	3	4	5	6	7
Number Returns	1	0	2	4	5	8	10

Foster-reared Chicks

The means and standard deviations of all dependent measures on foster-reared chicks are shown in Table 6. Foster-reared chicks were compared to normal-reared chicks (Group 6 from Daily-tested subjects). An F max test of the differences between variances of the two groups was not significant on any dependent measure (latency, $F<1$, $P.>.05$; time moving, $F=1.67$, $P.>.05$; orientation, $F=1.15$, $P.>.05$; distance, $F=1.78$, $P.>.05$) so a t-test was used to compare the two groups. No significant differences were found between the two groups on latency ($t<1$, $P.>.05$), time moving ($t<1$, $P.>.05$), orientation ($t<1$, $P.>.05$) or distance ($t<1$, $P.>.05$).

Relocations

All subjects were not found for each weekly test session (see Table 30, Appendix), which may have led to a systematic bias in the data since chicks recaptured may be those with strong preferences while those not found may have weak or no area preferences. If this were the case, only chicks with strong area preferences would be included in the sample. The data were inspected, therefore, to determine if the same chicks were being found weekly. As shown by Table 30, this was not the case. Only 9 chicks had complete records for the 5 weeks. Omissions were generally due to a chick not being located for one or two of the 5 weeks. Since this was the case, subject means were substituted for missing cells for analysis. The means and standard

Table 6

Means and Standard Deviations of Latency, Time Moving, Initial Orientation, and Final Distance from the Nest of Foster-reared and Normal-reared Chicks tested on Day 6 Post-hatch

Response Measure	Foster-reared Group	Normal-reared Group	Analysis
Latency (in seconds)	$\bar{X}$ = 23.58 S.D. = 51.26	$\bar{X}$ = 20.83 S.D. = 46.41	t<1, N.S.
Time Moving (in seconds)	$\bar{X}$ = 69.58 S.D. = 78.33	$\bar{X}$ = 78.33 S.D. = 72.74	t<1, N.S.
Initial Orientation (in degrees)	$\bar{X}$ = 11.25 S.D. = 26.78	$\bar{X}$ = 18.75 S.D. = 28.80	t<1, N.S.
Final Distance (in meters)	$\bar{X}$ = 14.17 S.D. = 4.34	$\bar{X}$ = 11.08 S.D. = 5.79	t=1.42, N.S.

deviations for all dependent measures in the weekly tests are presented in Table 7. Orientation data was incomplete for Week 5 and time moving for Weeks 4 and 5 due to weather and equipment failure, so these were not used in the analysis.

Latency. An F max test for homogeneity of variance was significant for latency (F max=4.02, P.<.01). A reciprocal transformation was done and both raw and transformed data analysed. No significant differences were found on either raw or transformed data (F=<1, P.>.05; F=1.58, P.>.05, respectively).

Time Moving. Time moving was not analysed because of the missing data for Weeks 4 and 5. It is evident from the data for Weeks 1-3 and from experimenter observation that time moving increased with age (see Table 7).

Orientation. An F max test for the homogeneity of variance was not significant for initial orientation (F max= 1.81, P.>.05). Analysis of variance indicated a significant difference among groups on orientation (F=13.45, P.<.001). A summary of this analysis is presented in Table 8. Individual comparisons (Studentized Range Statistic) revealed that the means of Week 1 and 2 (19.13, 24.64, respectively) were not different from each other but were significantly lower than the means of Week 3 and 4 (39.50, 58.22, respectively; F=24.77, P.<.007). The mean of Week 3 was also significantly lower than that of Week 4 (F=7.69, P.<.01).

Table 7

Means and Standard Deviations of Transformed Latency (Response Speed), Initial Orientation, Time Moving, Final Distance and Initial Distance from the Nest for Relocated Chicks during Weeks 1-5

Response Measure (N = 56)		Week 1	2	3	4	5
Response Speed (in seconds)	$\bar{X}$ =	.81	.83	.82	.79	.72
	S.D. =	.36	.34	.35	.38	.39
Initial Orientation (in degrees)	$\bar{X}$ =	19.13	24.64	39.50	58.22	--
	S.D. =	32.91	34.36	46.35	59.70	--
Time Moving (in seconds)	$\bar{X}$ =	19.39	30.25	65.23	--	--
	S.D. =	30.95	45.56	80.92	--	--
Final Distance (in meters)	$\bar{X}$ =	18.89	19.45	26.48	28.45	25.64
	S.D. =	16.52	13.82	19.90	26.73	23.63
Initial Distance (in meters)	$\bar{X}$ =	7.68	9.68	11.77	14.64	12.05
	S.D. =	8.54	12.74	19.31	30.37	17.65

Table 8

Summary of Analysis of Variance of Initial Orientation for Relocated Chicks during Weeks 1-5

Source	df	SS	MS	F	P
Age	3	51401.3	17133.8	13.4516	.0001
Age x Subjects	165	2101.7	1273.7		
Error	55	228511.0	4154.8		

Final Distance. An F max test of homogeneity of variance was not significant (F max=1.01, P.>.05). Analysis of variance revealed a significant difference among groups on final distance (F=2.93, P.<.02). A summary of this analysis is presented in Table 9. Individual comparisons (t-tests) showed that the mean distance was significantly lower for Weeks 1 and 2 ($\bar{X}$=18.89, 19.45, respectively) than for Weeks 3-5 ($\bar{X}$=26.48, 28.45, 25.64, respectively; F=6.31, P.<.01).

Initial Distance. An F max test for homogeneity of variance was not significant (F max=1.98, P.>.05). No differences among groups were found in analysis of variance (F=1.56, P.>.05).

Number Returns. A division was made of those chicks returning within 10 m. of the nest and those not reaching

Table 9

Summary of Analysis of Variance of Final Distance from the Nest for Relocated Chicks during Weeks 1-5

Source	df	SS	MS	F	P
Age	4	4211.82	1052.96	2.9280	.02
Age x Subjects	220	79116.90	359.62		
Error	55	38174.30	694.08		

this criterion (see Table 10). A chi square test showed that the number of returns was significantly greater than expected by chance for Week 1 and 2 chicks (chi=33.48, P.<.001; chi=12.26, P.<.001, respectively) and significantly less than expected for Week 4 and 5 chicks (chi=16.90, P.<.001; chi=11.22, P.<.001, respectively).

Table 10

Number of Chicks Reaching Nest Return Criterion on Relocations during Weeks 1-5

	Week				
	1	2	3	4	5
Number Returns	29	23	9	3	5

Correlations

Daily-tested Chicks. Table 11 presents the significant correlations with their associated probabilities obtained from the correlation matrix. The list of variables used in the correlation matrix is presented in Table 31, Appendix. A Pearson product-moment coefficient was used for interval and ratio data while a Spearman's rank coefficient was used for the ordinal data. Significant correlations that were not meaningful in terms of the present experiment are presented in Table 32, Appendix.

The chick's initial distance from the nest was negatively related to final distance from the nest (r_{xy}=-.34, P.<.001) and positively related to wind speed (r_{xy}=.24, P.<.03). There was a positive relationship between location vegetation type and time moving (rho=.27, P.<.01). The height of the location vegetation was also positively related to time moving (r_{xy}=.73, P.<.001) and negatively related to wind speed (r_{xy}=-.23, P.<.05). The density of the location vegetation was positively related to time moving (rho=.31, P.<.010) and negatively related to wind speed (rho=-.27, P.<.02). The denser the vegetation in which the chick was found, then, the higher the wind speed, and the longer the time the chick spent moving.

There was a positive relationship between vegetation height at the release point and time moving (r_{xy}=.46, P.<.001). Vegetation height at the final resting location was negatively related to final distance (r_{xy}=-.22, P.<.04). There was a

Table 11

Significant Correlation Coefficients and Probability Levels for Chicks Tested during the First Week Post-hatch

Variable	Correlation Coefficient	P
1. Initial and final distance from the nest	r_{xy}=-.34	.001
2. Initial distance from the nest and wind speed	r_{xy}= .24	.030
3. Location vegetation and time moving	rho= .27	.010
4. Location vegetation height and time moving	r_{xy}= .73	.001
5. Location vegetation height and wind speed	r_{xy}=-.22	.050
6. Location vegetation density and time moving	rho= .31	.010
7. Location vegetation density and wind speed	rho=-.27	.020
8. Release vegetation height and time moving	r_{xy}= .46	.001
9. Final vegetation height and final distance	r_{xy}=-.22	.040
10. Final distance and wind speed	r_{xy}= .27	.010
11. Nest site and location vegetation type	rho= .51	.001
12. Location vegetation and final vegetation type	rho= .36	.010
13. Release vegetation and final vegetation type	rho= .37	.010
14. Initial orientation and final distance from the nest	r_{xy}= .26	.020
15. Initial orientation and latency	r_{xy}= .24	.040

positive relationship between final distance from the nest and wind speed (r_{xy}=.27, P.<.01) and between the vegetation type at the nest and at the collection point (rho=.51, P.<.001). Final vegetation type was also positively related to location vegetation type (rho=.36, P.<.01) and release vegetation type (rho=.37, P.<.01). Finally, there was a positive relation between initial orientation and final distance from the nest (r_{xy}=.26, P.<.02) and initial orientation and latency (r_{xy}=.24, P.<.04).

Relocations. The significant correlations and their associated probabilities are shown in Table 12. Correlation matrices were also calculated for each weekly relocation. Since the same significant relations were found for each week, only the pooled data is presented.

A positive relationship was found between initial and final distance from the nest (r_{xy}=.64, P.<.0001). Vegetation type at the collection point was positively related to both the nest site vegetation type (rho=.49, P.<.0001) and the vegetation type at the final resting location (rho=.49, P.<.0001). Moreover, the vegetation type at the nest site and the vegetation type at the final resting location were also positively related (rho=.62, P.<.0001). Initial orientation was positively related to final distance from the nest (r_{xy}=.43, P.<.0001). Finally, time moving was positively related to both location vegetation type (rho=.33, P.<.001) and final vegetation type (rho=.51, P.<.0001).

Table 12

Significant Correlation Coefficients and Probability Levels for Relocated Chicks during Weeks 1-5

Variable	Correlation Coefficient	P
1. Initial and final distance from the nest	r_{xy}=.64	.0001
2. Location and final vegetation type	rho=.49	.0001
3. Location and nest site vegetation type	rho=.49	.0001
4. Nest site and final vegetation type	rho=.62	.0001
5. Final distance and initial orientation	r_{xy}=.43	.0001
6. Time moving and location vegetation type	rho=.33	.0010
7. Time moving and final vegetation type	rho=.51	.0001

Discussion

The data support the hypothesis that during the first week post-hatch Herring Gull chicks exhibit an attachment to the nest site area. The increasing number of returns to the nest and the decrease in the distance from the nest with increasing age indicate that attachment is optimal on Day 6-7 post-hatch. The failure to demonstrate a preference earlier than this is probably due to a performance difficulty in very young chicks, rather than a lack of attachment to the nest area. During the first three days of testing, a majority of test chicks remained quite near the release point while many

did not move at all. This lack of mobility in very young chicks has also been reported for Laughing Gull chicks (Beer, 1969). However, the degrees deviance of orientation to the nest of 1-3 day old chicks was less than half that of older chicks ($\bar{X}$=12.5, 29.1, respectively). This indicates that chicks could find the nest site but were unable to locomote the distance. Under undisturbed conditions, for example, test chicks (1-3 days old) rarely were observed 20 m. from the nest by the experimenters. Such excursions are usually limited by agonistic behaviour of birds from other nest territories.

Weekly relocation data revealed a decreasing nest site attachment with increasing age on all dependent measures which supports the prediction made. It is also evident that chick excursion areas enlarged with increasing age as shown by the increasing distance from the nest in which chicks were found and in which they relocated on testing over weeks.

Nest site attachment appears to be ecotypically controlled, as evidenced by the failure to find differences between foster and normal-reared chicks. It should be noted that foster chicks spent at least half of the incubation period in their natural nests, which had no apparent effect on their post-hatch behaviour. The period spent in foster nests was the latter half of incubation, which may be the more crucial period since embryos are more fully developed. It seems probable that a preference for the nest site area is conditioned as a result of the reinforcing events at the

nest area, for example, feeding, shelter, protection from predators, social stimulation, etc. At the same time, excursions outside this area are discouraged by the presence of other territories which are actively defended against intruders. The experimenters often observed a young chick of the study age passing through a foreign territory and being attacked by adults from the air and chicks on the ground. This mechanism of attachment could easily be tested in the laboratory by systematically introducing feeding, shelter, social stimulation, etc., into a rearing area and testing for a rearing area preference after each presentation. These stimuli could then be systematically removed to determine if and when the preference breaks down. In this way an indication of what stimuli are necessary to establish and maintain rearing area preferences could be obtained.

Correlational data indicated that vegetation characteristics were among the cues used in relocating the nest site. The vegetation type in which chicks were found, both before and after testing, was usually the same as the nest site vegetation type. It appears, therefore, that chicks come to prefer the vegetation surrounding the nest, and when extended excursions occur, restrict their activities to areas of the same or similar vegetation. The importance of vegetation characteristics in nest site selection has been reported by Bongiorno (1970) for adult Laughing Gulls and by Anderson (1971) for Prairie Chickens. It may be then, that both young and adults use vegetation cues and that vegetation

preferences developed early in life are continued into adulthood. Therefore, a long term study should be done of the behaviour of chicks from hatching to the first nesting season to determine if in fact young and adults use the same nest site cues and whether early nest site preferences influence later nest site selection. LeResche & Sladen (1970) have done a comparable study although they did not investigate cues in nest site selection but rather the incidence of adults nesting in their natal sites. They found that 40% of first year breeders in an Adelie Penguin colony selected nest sites within 200 meters of their natal sites.

The possibility that chicks were using sky cues to relocate the nest was examined by comparing testing with the wooden carrying box using an opague and a transparent cover. Twelve chicks were tested under each condition using identical procedures to those previously described. No differences were found between the two groups on any dependent measure.

The present study indicates a heavy reliance on visual stimuli as cues in nest site relocation. Whether in fact vision is necessary in nest site recognition is examined in Experiment 2. Auditory stimuli may also be used as cues to relocate the nest site. During testing, adults were observed constantly vocalizing from the air. Although it was not possible to identify which birds were the parents of the test chicks, it was possible that parent vocalization could aid chicks in relocating the nest area. Observations

of marked adults during testing or testing deafened chicks could be done to examine this possibility. In addition, the presence of chicks at the nest may be used as cues in nest relocation. Later experiments evaluate the role of other chicks in attachment to and recognition of the nest site.

Experiment 2. The Role of Vision in Nest Site Attachment and Recognition

Although the importance of vision in initiating approach responses to moving objects and conspecifics has been demonstrated (Bateson, 1966; Evans, 1972), little data has been reported on the role of vision in the development of preferences for and recognition of rearing areas. Anderson (1971) reported that Prairie Chickens use visual clues, such as vegetation height and composition, to establish territorial boundaries and are strongly attached to these. The preferences for vegetation exhibited by young Herring Gull chicks (Experiment 1) indicate also that visual stimuli are important in nest site recognition. Evans' (1970a) study of preferences for a rearing chamber in young Ring-billed Gull chicks also supports this hypothesis. In these experiments, however, other sensory modalities, which were operative, could also affect recognition and attachment. The present study was designed, therefore, to assess the necessity of vision in nest site attachment and recognition.

Method

Subjects

Twenty-four Herring Gull chicks were randomly selected from Little Bell Island. Chicks were chosen from three-egg clutches, and were individually marked after hatching. The location of the nest was recorded, as well as the type, height and density of vegetation surrounding the nest.

Chicks were divided equally into two groups. Group 1 were to be fitted with hoods, made of white nylon baby socks, to occlude vision (see Fig. 4). The hood area directly over the eyes consisted of raised hemispheres, stiffened with white nail polish to provide translucent surfaces and prevent direct contact with the eye. Group 2 were to be fitted with the same kind of hoods with no eye occluders. Normal chicks were Day 7 chicks from Experiment 1. Daily health checks were made on all chicks.

Procedure

The testing procedure was to be the same as that described for daily-tested chicks in Experiment 1. Initially the test hoods were placed on 6 subjects which were checked two hours later. Two of these subjects were observed via a telescope for one hour after hood fitting. The chicks generally remained quiescent at the nest. The parent gulls, however, on aerial inspection of their nest, appeared very disturbed. Both parents were observed to frequently emit distress calls during the observation period, swoop close to the nest, but not alight. Since other parents in the area were alighted at their nests, this behaviour was interpreted to be a reaction to the visual appearance of the hooded chicks in the nest. Consequently, a period of three and one half hours was spent observing two additional chicks. Records of parent and chick behaviour were taken at 5 min. intervals. It was found that during the entire period neither parent approached the nest, even during distress

FIG. 4. Herring Gull Chick Wearing Experimental Hood Used to Occlude Vision

vocalization by chicks. The same disturbed behaviour present in the first hour of observation was also evident.

Since parents would not approach the nest during a 3½ hour period it was concluded that hooded chicks would not survive since this amount of time would exceed the necessary brooding and feeding interval, at least for the first few days post-hatch (Baerends et al, 1970). The experiment as proposed was therefore not feasible. It appeared that the visual appearance of hooded chicks was not acceptable to parent gulls. To complete this experiment successfully, then, it would be necessary to use occluders that did not drastically change the visual appearance of chicks. Contact lenses would fulfil this requirement. However, difficulties of using these in the field, of allaying infection, and of developing maintenance techniques could not be overcome in the short period of time left in the nesting season.

Although the necessity of vision for nest site attachment could not be evaluated, it was still possible to obtain some indication of the necessity of vision to nest site recognition. Six chicks, 7 days post-hatch, were fitted with occluder hoods, given a 10 min. period to adapt to the hood, and were then tested for nest site relocation using the same procedures as described in Experiment 1. However, the test period was extended to 30 min.

Results

Hooded chicks were compared to Day 7 chicks from Experiment 1. The means and standard deviations of all dependent measures are presented in Table 13. An F test for the differences between variances was significant on time moving ($F=7.05$, $P.<.002$) and latency ($F=8.10$, $P.<.001$), so a Welch t prime approximation (Ferguson, 1966) was used to compare groups on these measures. A t-test was used for distance and initial orientation. Results showed a significant difference between groups on initial orientation ($t=4.65$, $P.<.003$), final distance ($t=2.66$, $P.<.02$) and latency ($t'=4.07$, $P.<.01$). The hooded group exhibited longer latencies, were further from the nest and exhibited a greater deviance in initial orientation than did the normal group. The data was also inspected to determine if hooded chicks relocated in similar vegetation to that at the collection point. No significant trends were detected, 3/6 chicks settled in the same vegetation type as surrounded the nest, 3/6 did not. However, 5/6 chicks relocated in vegetation of similar height and density to that of the collection point.

Discussion

Loss of vision significantly affects nest site recognition at least in visually experienced animals. To evaluate the effect of visual deprivation on naive chicks it would be necessary to occlude vision from hatching as

Table 13

Means and Standard Deviations of Time Moving, Initial Orientation, Latency, and Final Distance from the Nest for Hooded and Normal Chicks, Experiment 2

Response Measure		Hooded Group	Normal Group	Analysis
Time Moving	$\bar{X}$ =	83.67	108.17	t'=1.34, N.S.
(in seconds)	S.D.=	75.06	59.23	
Initial Orientation	$\bar{X}$ =	112.50	19.58	t=4.65, P.<.003
(in degrees)	S.D.=	50.31	22.61	
Final Distance	$\bar{X}$ =	23.83	11.00	t=2.66, P.<.020
(in meters)	S.D.=	7.54	10.80	
Latency	$\bar{X}$ =	422.50	2.08	t'=4.07; P.<.009
(in seconds)	S.D.=	252.85	5.82	

previously described. It is quite possible that the lack of any visual experience in naive chicks may be compensated for by using other sensory modalities to orient to the nest area. Such chicks may in fact be able to locate their nests using auditory or tactile stimuli. The fact that in this experiment visually experienced animals responded to such cues as height and density of vegetation supports this speculation. The experiment as originally planned would have to be done to investigate this possibility. The present data indicate that under normal conditions, vision is heavily relied upon in nest site recognition.

The reaction of parents to hooded chicks poses an interesting problem. Data on individual recognition of chicks by parents (Smith, 1966; Tinbergen, 1953; Cullen, 1957) make it seem unlikely that parents were reacting to their own chicks since this reaction was present on Day 1 post-hatch. It is more probable that parents were exhibiting species recognition of chicks and that deviation from this norm was not acceptable. This could be tested by using first year breeders that do not have experience with previous broods, or by using occluders that do not change the visual appearance of chicks, i.e. contact lenses. It is also possible that parents were reacting to a change in the nest site stimuli since chicks are normally a part of the stimulus configuration of the nest. Data obtained in later work do in fact indicate that changes in the nest site stimuli, i.e. placing strange chicks at the nest, will disrupt behaviour of adults.

Experiment 3. The Role of Stimulus "Conspicuousness" and "Landmarks" in Nest Site Recognition

It has been suggested that birds recognize their nest areas by the "conspicuousness" of the visually prominent features of the habitat, such as landmarks and vegetation (Lack, 1933; 1954). Experimental evidence supports this suggestion for adults. Tinbergen (1953) demonstrated that relocation of a visually prominent landmark correspondingly disoriented adult Herring Gulls from the nest. Baerends et al (1970) reported that relocation of a landmark facilitated acceptance of a displaced nest by Herring Gulls. Anderson (1971) has shown that Prairie Chickens, Tympanuchus cupido Linnaeus, use major differences in the height and composition of vegetation to establish territorial boundaries and are strongly attached to these stimuli. Although "conspicuousness" has been advanced as a major stimulus characteristic controlling early stimulus preferences in young birds (Bateson, 1966), no data have been reported on the cues used by chicks in recognition of rearing or nest areas. Stationary imprinting studies (Bateson, 1964b; 1966) indicate that conspicuous stimuli are effective in establishing preferences for static objects. Correlational data from Experiment 1 also indicate that vegetation characteristics, important in adult recognition, are also among the cues used by neonatal Herring Gull chicks in relocating the nest area. The present experiment was designed to determine whether conspicuousness

of stimuli serves as a cue in nest site recognition by chicks and whether relocation of a conspicuous landmark would cause a corresponding disorientation from the nest.

Method

Subjects

A sample of 18 Herring Gull chicks was randomly selected from grass vegetation on Little Bell Island. Chicks were chosen from three-egg clutches and were individually marked after hatching so that age could be accurately determined from the date of hatching. The location of each nest site was recorded on a grid map of the island, and the height, type and density of the surrounding vegetation recorded as described previously (Experiment 1). Chicks were tested on Day 6 post-hatch.

Procedure

Prior to chick hatching, artificial landmarks consisting of fir trees, were placed vertically 1 m. NE of the test nests. Conspicuousness was assumed to vary with the height of these trees. Three heights were used: (1) 1.5 m. conspicuous, (2) 1 m. moderately conspicuous, and (3) .5 m. low conspicuous (see Figs. 5, 6, and 7, respectively).

All chicks were tested under two conditions. In one condition the landmark was moved 5 m. NE of the nest and in the second condition the landmark remained in its original position. To control for possible order effects, half of the chicks were tested under the above schedule while the

FIG. 5. Fir Tree Used as a Highly Conspicuous Landmark in Experiment 3

FIG. 6. Fir Tree Used as a Moderately Conspicuous Landmark in Experiment 3

FIG. 7. Fir Tree Used as a Low Conspicuous Landmark in Experiment 3

half were tested with the order reversed, i.e. landmark in its original position followed by the landmark moved.

For testing the chick was removed from the nest area, placed in the wooden carrying box, and removed 5 m. from the nest for a period of three minutes. During this time the landmark was moved for half of the chicks, and left unaltered for the other half. The chick was then transported 20 m. from the nest in a random direction and released.

Following completion of the first trial, the chick was retested in the same way, except that the position of the landmark was reversed. That is, if on the first trial the chick was tested with the landmark moved, then on the second trial, the landmark was unaltered for testing, and vice versa. Movement latency (in seconds), time moving (in seconds), initial orientation (in degrees deviance from a straight line to the nest), and final distance from the nest (in meters) were recorded. Testing was terminated when the chick was within one meter of the nest site or was immobile for 10 min. All chicks were returned to the collection point after testing.

Results

The means and standard deviations for all dependent measures are presented in Table 14.

Latency. An F max test for homogeneity of variance was significant for latency (F max=30.00, P.<.01). A reciprocal transformation was performed on latency and both

Table 14

Means and Standard Deviations of Transformed Latency (Response Speed), Time Moving, Initial Orientation and Final Distance from the Nest for Chicks in Experiment 3

		Conspicuous Level											
		High				Moderate				Low			
Order of Landmark Position		M1**	M2	M2	M1	M1	M2	M2	M1	M1	M2	M2	M1
Response Speed (in seconds)	$\bar{X}$ =	.38	1.00	.39	.75	.68	.70	1.00	.70	1.00	1.00	.70	1.00
	S.D.=	.53	0.00	.52	.43	.55	.52	0.00	.52	0.00	0.00	.52	0.00
Time Moving (in seconds)	$\bar{X}$ =	83.67	59.00	60.00	38.33	45.00	59.33	107.00	64.67	72.00	52.00	118.67	49.00
	S.D.=	95.08	10.81	10.00	33.59	21.79	46.75	59.09	14.50	57.24	20.30	101.44	19.47
Initial Orientation (in degrees)	$\bar{X}$ =	45.00	0.00	33.33	60.00	60.00	0.00	75.00	16.67	30.00	0.00	30.00	30.00
	S.D.=	0.00	0.00	20.21	51.96	25.98	0.00	25.98	28.87	25.98	0.00	51.96	25.98
Final Distance (in meters)	$\bar{X}$ =	13.67	8.67	11.00	12.67	17.33	7.00	22.00	18.33	14.33	12.33	20.33	14.67
	S.D.=	7.50	3.51	7.50	10.12	1.21	9.50	11.36	.63	7.33	4.16	8.74	4.11

**M1=Landmark Moved; M2=Landmark Unaltered

raw and transformed data analysed. Analysis of variance revealed no significant differences on either raw or transformed data.

Time Moving. An F max test of homogeneity of variance of time moving was significant (F max=8.64, P.<.05). A log transformation of time moving was performed and both raw and transformed data analysed. Analysis of variance showed no significant differences on either raw or transformed data.

Orientation. An F max test for homogeneity of variance was not significant (F max=4.01, P.>.05). Analysis of variance indicated a significant main effect of landmark position on nest site orientation (F=10.05, P.<.008). A summary of this analysis is presented in Table 15. The mean degrees deviance from the nest for the landmark moved condition was 45.56 while the mean degrees deviance for the landmark unaltered was 17.78. Testing with the landmark then led to significantly greater deviance from the straight line to the nest than did testing with the landmark unaltered. Orientation to the landmark itself was significantly more deviant in the moved condition ($\bar{X}$=21.1) than in the unaltered condition of the landmark ($\bar{X}$=16.1; t=4.6, P.<.01). However, orientation on the landmark itself was significantly less deviant than orientation to the nest ($\bar{X}$=21.1; 45.56, respectively, t=8.21, P.<.01) in the moved condition while no difference occurred in the unaltered condition ($\bar{X}$=16.1, 17.78, orientation to the landmark and the nest respectively, t<1, P.>.05).

Table 15

Summary of Analysis of Variance of Initial Orientation, Experiment 3

Source	df	SS	MS	F	P
Conspicuousness Level	2	1579.17	789.58	1.0	N.S.
Order	1	3025.00	3025.00	3.49	N.S.
C x O	2	154.16	77.08	1.0	N.S.
Error	12	10391.97	865.97		
Landmark Position	1	6944.44	6944.44	10.05	.01
C x L	2	4484.72	2242.36	3.25	N.S.
O x L	1	2669.43	2669.43	3.86	N.S.
C x O x L	2	1859.71	929.86	1.35	N.S.
L x E	12	8291.65	690.97		

Final Distance. An F max test for homogeneity of variance was not significant (F max=3.60, P.>.05). A significant main effect of landmark position on final distance was found in analysis of variance (F=5.53, P.<.03). A summary of this analysis is presented in Table 16. The mean distance from the nest for the landmark moved condition was 16.44 while the mean distance for the landmark unaltered condition was 12.27. Final distance from the nest was lower when the landmark was in its original position during testing than when it was moved.

Discussion

The results support the hypothesis that landmarks are among the cues used in nest site recognition and that changing the stimulus configuration of the nest causes disorientation. Testing with the landmark moved resulted in greater deviance in initial orientation to the nest and greater distance from the nest than did testing with the landmark in its original position. This data agrees with that of Tinbergen (1953) which demonstrated that adult Herring Gulls are also disoriented by movement of a prominent landmark. Young and adults then may use similar cues in nest site recognition.

The possibility exists that the movement main effect was in part due to experimental manipulation, that is the act of moving the landmark disrupted behaviour. However, care was taken to treat subjects under moved and unaltered conditions in the same way. The time periods in the carrying

Table 16

Summary of Analysis of Variance of Final Distance from the Nest, Experiment 3

Source	df	SS	MS	F	P
Conspciuousness Level	2	150.72	75.36	1.12	N.S.
Order	1	164.69	164.69	2.45	N.S.
C x O	2	80.72	40.36	1.00	N.S.
Error	12	806.66	67.22		
Landmark Position	1	156.25	156.25	5.53	.03
C x L	2	43.17	21.58	1.00	N.S.
O x L	1	23.36	23.36	1.00	N.S.
C x O x L	2	53.40	26.69	1.00	N.S.
L x Error	12	339.33	28.28		

box were identical, the chicks were placed in the carrying box before any manipulations took place, and the experimenters attempted to behave in the same manner during the three minute interval whether or not the landmark was being moved. It appears, therefore, unlikely that an experimenter effect is present. Moreover, the fact that orientation to the landmark was superior to orientation to the nest in both moved and unaltered conditions indicates that chicks were responding to the landmark and not to movement per se.

The failure to find differences across landmark height levels may be related to the scale of "conspicuousness" chosen. It is evident from Figs. 5, 6, and 7 that although the three height levels are distinguishable to the human eye, each may serve as a conspicuous object within the surrounding vegetation to a Herring Gull chick. For this reason, low conspicuous trees may be just as effective a stimulus as highly conspicuous trees when both are against a low grass background. To test this, landmarks which are at the same level as the surrounding vegetation could be included in the scale. Alternatively, to evaluate the role of conspicuous stimuli a large area surrounding the nest could be levelled so that no conspicuous landmarks were available.

A further reason for the failure to find conspicuousness differences may be that a combination of cues is used in nest relocation and that conspicuous stimuli exist in other sensory modalities. It is possible, for example, that horizontal cues could be used on Little Bell Island in

relocating nests. This may be evaluated by testing chicks in fog versus no fog or with a line of sight to the nest versus no line of sight to the nest. Visual and auditory stimuli provided by siblings and parents may also be important in nest relocation. The latter suggestion is assessed in later experiments.

Experiment 4. The Development of Individual Recognition among Herring Gull Chicks

Individual recognition has been hypothesized to be one important mechanism that maintains family unity in ground nesting precocial species (Alley & Boyd, 1950; Davies & Carrick, 1962; Hailman, 1962; Bateson, 1966). Reciprocal recognition of young (Tinbergen, 1953; Cullen, 1957; Smith, 1966) and parents (Tinbergen, 1953; Hailman, 1962; Beer, 1969; Evans, 1970b) has been demonstrated in several species at approximately one week post-hatch.

The relatively high cohesion of sibling groups, particularly during the first week of life (Evans, 1970a), could indicate that individual recognition of brood siblings also occurs at an earlier age. This has been demonstrated for Ring-billed Gull chicks that recognize siblings on Day 4 post-hatch (Evans, 1970a). If sibling recognition is evident among Herring Gull chicks during the first week post-hatch, then social stimulation provided by siblings may be an important stimulus in nest site attachment and recognition during this period. The present experiment was designed as a preliminary study to determine if individual recognition occurred among Herring Gull siblings, and if so, to determine its chronological development.

Method

Subjects

A sample of 15 Herring Gull chicks was randomly selected from the study site on Little Bell Island. Chicks were selected from three-egg clutches, individually marked on the day of hatching and the nest site location recorded. Testing began on Day 2 post-hatch.

Apparatus

The test apparatus consisted of a rectangular wooden runway, measuring 50 cm. x 100 cm. x 30 cm., separated into three compartments by wire screens placed 15 cm. from each end of the apparatus (see Fig. 8). The runway was covered by a plexiglass sheet to prevent chicks from escaping.

Procedure

Stimulus chicks, one a sibling and the other a non-sibling, were placed in each end compartment of the apparatus. The test chick was placed in the centre of the middle compartment (35 cm. from the wire screens) to begin testing. Latency to first movement, total time moving and the stimulus chick the subject approached were recorded. Vocalization of both test and stimulus chicks was noted. The end containing the sibling was alternated to control for any place response. Testing was terminated when the chick made a choice (within 5 cm. of a wire screen for 45 sec.), or was immobile for 10 minutes.

FIG. 8. Apparatus Used to Test Individual Recognition Among Siblings in Experiment 4

Results

On Day 2 post-hatch, 12 of the 15 chicks chose the sibling (chi=5.4, P.<.02). Since chicks exhibited recognition at this age, testing was terminated. On 7 of the 12 correct responses, vocalization by one or more of the chicks was evident. A comparison of trials on which any vocalization occurred and those on which no vocalization occurred was done for latency and time moving. No significant differences were found on either latency ($t<1$, $P.>.05$) or time moving ($t=1.94$, $P.>.05$) between vocalization and non-vocalization trials (see Table 17).

Table 17

Latency (in seconds) and Time Moving (in seconds) on Vocalization and No Vocalization Trials in Experiment 4

Trials	N	$\bar{X}$ Latency	Analysis	$\bar{X}$ Time Moving	Analysis
Vocalization occurring	7	23.8	$t<1$, $P.>.05$	58.0	$t=1.94$, $P.>.05$
No Vocalization occurring	5	23.0		74.0	

Six additional chicks were tested on Day 1 post-hatch to determine whether recognition occurred earlier than Day 2. None of the Day 1 chicks made the correct choice, 4 of the 6 making no choice after 10 min.

Discussion

Results indicate that individual recognition among Herring Gull siblings occurs by Day 2 post-hatch. This is earlier than reported for Ring-billed gull chicks that exhibit sibling recognition on Day 4 post-hatch (Evans, 1970a). It is also as early as or earlier than parental recognition which is clearly evident on Day 6 post-hatch in Laughing gulls (Beer, 1969), and on Day 2-3 post-hatch in Black-billed gulls (Evans, 1970b). The early onset of sibling recognition does suggest that siblings as a source of social stimulation would be important in family cohesion and nest site attachment evident during the first week after hatching. This possibility is examined in following experiments.

Vocalization does not appear to be necessary for individual recognition, since no differences were found between trials on which vocalization occurred and those on which none occurred. Moreover, 5 of the 12 correct choices were made in the absence of any vocalization evident to the experimenter. It seems, therefore, that Herring Gull chicks can recognize each other using visual stimuli. It should be noted, however, that the failure to find vocalization differences may be related to the gross measure used. That is, there was not sufficient data to analyse vocalization differentially by source, i.e., test chick, sibling, etc. in which differences would be most likely to be evident.

Furthermore, pooling such sources as was done here would tend to cancel any differences. Therefore, although chicks can recognize each other visually, it is quite possible that vocalization would have a facilitatory effect upon recognition. The enhanced effect of combined visual and auditory stimuli on recognition has been reported by Evans (1970b), as has the ability of gull chicks to recognize each other visually.

Experiment 5. The Role of Social Stimulation in Nest Site Attachment and Recognition in Herring Gull Chicks

Social stimulation has been postulated to be an important factor in establishing habitat preferences, particularly in such gregarious species as gulls (Klopfer & Hailman, 1965). Although social stimulation in the form of the presence of other gulls is known to enhance the formation of early spring 'club' aggregations (Tinbergen, 1953) and the selection of feeding areas (Frings et al, 1955) in Herring Gulls, little is known about the effect of social stimulation on nest site attachment. Since Herring Gull chicks exhibit individual recognition as early as Day 2 post-hatch, it seems likely that other chicks could serve as important stimuli in nest site attachment during the first week after hatching. The presence of other chicks may serve as social stimuli in nest attachment in at least two ways, (1) the presence of other chicks in social testing may facilitate attachment, and (2) chicks at the nest site may serve as discriminative stimuli in nest relocation. Since Herring Gull chicks exhibit individual recognition early in the first week of hatching, both of the above may vary according to whether or not chicks are siblings or non-siblings. The present experiment, was, therefore, designed to determine whether social stimulation by other chicks enhances nest site attachment, whether such stimuli serve as discriminative stimuli for nest site recognition, and whether these effects vary with sibling and non-sibling stimulation.

Method

Subjects

A sample of 36 Herring Gull chicks was randomly selected from the study site on Little Bell Island. Chicks were chosen from three-egg clutches and were individually marked on the day of hatching so that age could be accurately determined. The location of the nest site was recorded on the grid map of the island. Chicks were tested on Day 6 post-hatch, and were assigned to one of six testing conditions presented in Table 18.

Table 18

Experimental Design of Experiment 5

	Siblings at nest	Non-siblings at nest	No chicks at nest
Individually tested	N=6	N=6	N=6
Socially tested	N=6	N=6	N=6

Procedure

On Day 6 post-hatch, chicks were removed from the nest site, placed in the wooden carrying box previously described, transported 10 m. from the nest in a random direction and released. The 10 m. distance was used in order to maximize

the chances that test chicks could perceive conditions at the nest. Movement latency (in seconds), time moving (in seconds), initial orientation (in degrees deviance from a straight line to the nest) and final distance from the nest (in meters) were recorded. Testing was terminated when the chick was within one meter of the nest site or was immobile for 10 minutes. All chicks were returned to the collection point after testing. Group tested chicks were tested in the same way except in groups of two.

Additionally, to determine the effect of social stimulation on area preferences and excursion patterns of older chicks, 12 chicks were selected from the above sample for retesting on Day 12 post-hatch. Chicks were relocated as described in Experiment 1. Once a chick was located, its identification and location were recorded. The chick was then transported 20 m. to a different vegetation type and released with a stimulus chick. This was a sibling for half of the chicks and a non-sibling for the other half. Retesting procedure was the same as above.

Results

The means and standard deviations of all dependent measures are shown in Table 19 (see Table 33, Appendix, for corresponding raw and transformed data summaries).

Latency. A test for homogeneity of variance was significant for latency ($F_{max}=51.02$; $P.<.01$). Latency was then transformed into response speed using a reciprocal

Table 19

Means and Standard Deviations of Transformed Latency (Response Speed), Initial Orientation, Time Moving and Final Distance from the Nest, Experiment 5

	Response Measure		Siblings at Nest	Non-siblings at Nest	No Chicks at Nest
Individual Test	Response Speed (in seconds)	$\bar{X}$ =	.84	.53	1.00
		S.D.=	.40	.51	0.00
	Initial Orientation (in degrees)	$\bar{X}$ =	7.50	15.00	24.20
		S.D.=	18.40	23.24	36.66
	Time Moving (in seconds)	$\bar{X}$ =	75.00	60.50	92.50
		S.D.=	33.90	37.59	56.37
	Final Distance (in meters)	$\bar{X}$ =	3.67	17.17	10.00
		S.D.=	2.93	19.61	7.64
Social Test.	Response Speed (in seconds)	$\bar{X}$ =	.35	1.00	.69
		S.D.=	.50	0.00	.48
	Initial Orientation (in degrees)	$\bar{X}$ =	30.00	30.00	7.50
		S.D.=	46.47	73.48	18.37
	Time Moving (in seconds)	$\bar{X}$ =	80.70	89.17	102.00
		S.D.=	60.93	77.81	40.02
	Final Distance (in meters)	$\bar{X}$ =	5.83	13.17	8.0
		S.D.=	3.37	7.44	6.23

transformation. Analysis of variance of transformed data yielded a significant interaction of nest and test conditions ($F=5.06$, $P.<.01$) on response speed. A summary of this analysis is shown in Table 20. (See Table 34, Appendix, for raw data summary). Figure 9 presents a graphic representation of this interaction. Individual comparisons (t tests, Winer, 1971) showed that individually tested chicks had a lower mean response speed ($\bar{X}=.53$) when non-siblings were at the nest than when no chicks were at the nest ($\bar{X}=1.00$; $F=4.41$, $P.<.04$). Socially tested chicks had a lower mean response speed when siblings were at the nest ($\bar{X}=.35$) than when non-siblings were at the nest ($\bar{X}=1.00$; $F=4.80$, $P.<.03$). Additionally, socially tested chicks had a lower response speed ($\bar{X}=.35$) than individually tested chicks ($\bar{X}=.84$) when siblings were at the nest ($F=4.80$; $P.<.03$), and a higher response speed ($\bar{X}=1.00$) than individually tested chicks ($\bar{X}=.53$) when non-siblings were at the nest ($F=4.41$, $P.<.04$).

Time Moving. An F max test for homogeneity of variance was significant for time moving (F max=9.33, $P.<.05$). A reciprocal transformation was then performed and transformed data analysed. No significant differences were found in analysis of variance.

Initial Orientation. An F max test of homogeneity of variance was not significant (F max=5.41, $P.>.05$). Analysis of variance showed no significant differences among groups on initial orientation.

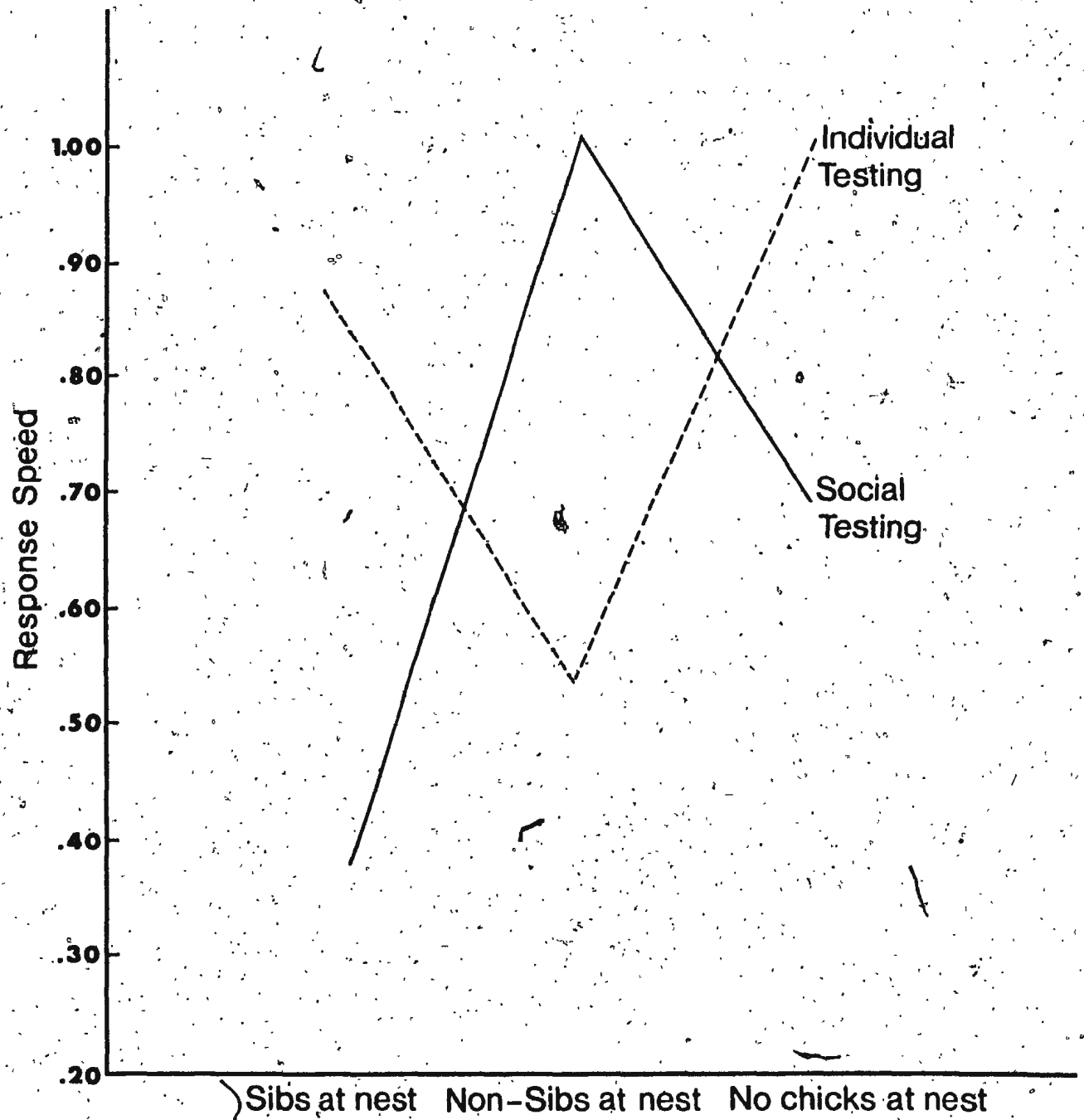


FIG. 9. Interaction of Nest and Test Condition on Response Speed (Transformed Latency), Experiment 5

Final Distance. An F max test for homogeneity of variance was significant for final distance (F max=47.07, P.<.01). A log transformation was then performed on final distance and both raw and transformed data analysed. Analysis of variance revealed a significant main effect of nest condition on final distance (F=3.55, P.<.04, see Table 35, Appendix, for corresponding transformed data analysis). A summary of this analysis is presented in Table 21. Individual comparisons showed that final distance from the nest was lower when siblings were at the nest ($\bar{X}$=4.75) than when non-siblings were at the nest ($\bar{X}$=15.17; F=7.01, P.<.01). The final distance from the nest when no chicks were at the nest ($\bar{X}$=9.0) did not differ from the other two conditions.

Chicks Released with Siblings and Non-siblings

Table 22 presents the means and standard deviations for all dependent measures.

Latency. An F test for the difference between variances of two groups (Winer, 1971) was significant for latency (F=7.92, P.<.01). A Welch t' (Ferguson, 1966) was then used to analyse the data. No significant difference was found on latency (t'=1.00, P.>.05).

Time Moving. An F test for the difference between variances was significant for time moving (F=4.40, P.<.03). A Welch t' was used to analyse the data and no significant difference was found between groups (t'=1.00, P.>.05).

Orientation. An F test for the difference between variances of two groups was significant (F=8.02, P.<.01).

Table 20

Summary of Analysis of Variance of Response Speed, Experiment 5

Source	df	SS	MS	F	P
Nest Condition	2	.3930	.1965	1.30	N.S.
Test Condition	1	.1098	.1098	1.00	N.S.
N x T	2	1.5355	.7677	5.06	.01
Error	30	4.5477	.1516		

Table 21

Summary of Analysis of Variance of Final Distance from the Nest, Experiment 5

Source	df	SS	MS	F	P
Nest Condition	2	658.39	329.19	3.55	.04
Test Condition	1	14.69	14.69	1.00	N.S.
N x T	2	59.39	29.69	1.00	N.S.
Error	30	2781.83	92.73		

Table 22

Time Moving, Initial Orientation, Latency, and Final Distance from Nest of Chicks Released with Siblings and Non-siblings, Experiment 5

Response Measure		Released With Siblings	Released With Non-siblings	Analysis
Time Moving (in seconds)	$\bar{X}$ =	49.50	49.17	$t' < 1.00$, N.S.
	S.D.=	47.25	22.53	
Initial Orientation (in degrees)	$\bar{X}$ =	46.67	00.00	$t' = 2.63, P. < .05$
	S.D.=	43.46	0.00	
Final Distance (in meters)	$\bar{X}$ =	20.00	9.67	$t' = 1.66$, N.S.
	S.D.=	14.35	5.12	
Latency (in seconds)	$\bar{X}$ =	0.00	3.67	$t' < 1.00$, N.S.
	S.D.=	0.00	8.98	

A Welch t' was used to analyse the data and a significant difference was found on orientation between chicks released with a sibling and those released with a non-sibling ($t'=2.63$, $P.<.05$). The mean degree deviance of chicks released with a sibling ($\bar{X}=46.67$) was greater than that of chicks released with a non-sibling ($\bar{X}=0.0$).

Final Distance. An F test for the difference between variances of two groups was significant for final distance from the nest ($F=7.86$, $P.<.01$). A Welch t' was used to analyse the data and no significant differences were found ($t'=1.66$, $P.>.05$).

It was also found that testing with a sibling or non-sibling had no effect on vegetation preferences. All chicks in both groups relocated in the same vegetation type as the one in which they were captured.

Discussion

The data support the hypothesis that social stimulation provided by other chicks serves as a cue for nest site recognition. A differential effect of sibling and non-sibling stimulation was found. Chicks were found closest to the nest when siblings were present at the nest site. Non-siblings, on the other hand, appear to adversely affect this behaviour since chicks were farthest from the nest when non-siblings were present at the nest site.

How chicks perceive the conditions at the nest site from the release point is an interesting problem. On a

majority of test trials, no vocalization by stimulus chicks was evident to the experimenter, which implies that auditory stimuli from other chicks were not being used. It is also unlikely that test chicks could see stimulus chicks 10 m. away since the latter usually hid in the nest vegetation. In the case of non-siblings at the nest, it may be that parent gulls perceived aerially the change in the nest situation and communicated a disturbance to their chicks. This would account for the difference between non-sibling and no chick conditions, since in the latter parents presumably would not be as disturbed. That such a reaction by parent gulls to strange nest conditions may occur appears plausible as results in Experiment 2 indicate.

Although social stimulation during testing did not seem to enhance nest returns, it did appear to facilitate nest returns according to the conditions at the nest. This is evident in the interaction of nest and test conditions on response speed. In a disturbed situation such as non-siblings at the nest, social stimulation facilitates the response perhaps by reducing fear or anxiety produced by the disturbance. Under normal conditions of siblings at the nest, however, social stimulation appears to inhibit nest return evident in individual testing. Recent studies by Hogan & Abel (1971) support this argument. They demonstrated that the presence of social companions reduces fear in an unfamiliar environment and that the visual stimuli provided by chicks are of primary importance for fear reduction.

These authors found similar differences between individually versus socially tested chicks. However, they found no differences between sibling and non-sibling stimulation. This disparity with the present results may be due to a species difference or to the differences in the experimental situations. For example, these authors used laboratory-reared animals and tested in the laboratory while the present one used animals reared and tested in a field situation.

Data on older chicks also indicates a differential effect according to sibling and non-sibling stimulation. The presence of a companion sibling during testing seemed to inhibit return to the nest while the presence of a non-sibling stimulated return to the nest. This behaviour would have an adaptive function, keeping chicks away from potential predators and close to the nest in any unusual circumstances.

Vegetation preferences do not appear to be influenced by social companions, at least once they are developed. All chicks released with a non-sibling relocated in the preferred vegetation regardless of where the non-sibling went. This is consistent with Bongiorno's (1970) argument that nest site selection in adult gulls is strongly dependent on their response to the habitat with social factors playing a secondary role. It appears that social stimulation is an important factor in young chicks' attachment to and recognition of the nest site and its effect varies with sibling and non-sibling stimulation.

Experiment 6. Effect of Rearing and Testing Conditions on Nest Site Recognition and Attachment in Herring Gull Chicks

The effect of social stimulation on nest site attachment and recognition may vary according to the rearing experience of young. This would seem particularly likely in view of the facilitatory effect of sibling over non-sibling stimulation on nest site return noted in the previous experiment. Evans (1970a) has investigated the effect of social versus isolate rearing and testing on home pen preferences in the laboratory. He found no differences between rearing conditions and the effect of testing conditions was not clear from his data. However, since a significant preference for the rearing area was not demonstrated, it seems probable that the experimental rearing situation did not include the relevant stimulus dimensions necessary for preference development in Ring-billed Gull chicks. This would account for the failure to find clear differences on rearing and testing conditions. Since it has been demonstrated that social versus individual stimulation conditions do have an effect on nest site returns, it seems reasonable to propose that there will be an effect of social rearing on returns to the nest. Therefore, the present experiment was designed to determine whether the effect of social versus individual testing conditions on nest site returns varied according to rearing experience in neonatal Herring Gull chicks.

Method

Subjects

A total of 24 Herring Gull chicks was randomly selected from the study site on Little Bell Island, so that half were from 3-egg clutches and half were from 1-egg clutches. Chicks were individually marked on the day of hatching and the nest site location recorded on the grid map of the island. Chicks were tested on Day 6 post-hatch and assigned to one of four experimental conditions as presented in Table 23.

Table 23

Experimental Design of Experiment 6

	Individual rearing	Social rearing
Individual testing	N=6	N=6
Social testing	N=6	N=6

Procedure

When the chicks achieved testing-age, they were removed from the nest site, placed in the wooden carrying box previously described, and transported 20 m. from the nest in a random direction and released. Movement latency (in seconds), time moving (in seconds), orientation (in degrees deviance from a straight line to the nest) and final distance from the nest (in meters) were recorded. Testing was terminated when the

chick was within one meter of the nest site or was immobile for 10 minutes. Social testing followed the same procedure except that chicks were tested in groups of two, so that three pairs were tested in each social condition. All chicks were returned to the collection point after testing.

Results

The means and standard deviations for all dependent measures are presented in Table 24.

Latency. An F max test for homogeneity of variance of latency was significant (F max=1406.26, P.<.001). Latency was then transformed into response speed using a reciprocal transformation. Analysis of variance showed no significant differences on latency (see Appendix, Tables 36 & 37). However, a significant main effect of testing was found on response speed (F=8.21, P.<.01). A summary of this analysis is presented in Table 25. Chicks tested individually had a higher response speed ($\bar{X}$=.85) than did chicks tested socially ($\bar{X}$=.36), regardless of rearing conditions.

Time Moving. An F max test for homogeneity of variance of time moving was not significant (F max=5.32, P.>.05). Analysis of variance showed no significant differences among groups on time moving.

Orientation. An F max test for homogeneity of variance was not significant (F max=12.51, P.>.05). Analysis of variance revealed no significant differences among groups on initial orientation (F=.53, P.>.05).

Table 24

Means and Standard Deviations of Transformed Latency (Response Speed), Initial Orientation, Time Moving, and Final Distance from the Nest, Experiment 6

	Response Measure		Reared Individually	Reared Socially
Testing Individually	Response Speed (in seconds)	$\bar{X}$ =	.86	.83
		S.D.=	.34	.40
	Orientation (in degrees)	$\bar{X}$ =	15.00	22.50
		S.D.=	23.24	37.65
	Time Moving (in seconds)	$\bar{X}$ =	81.67	74.33
		S.D.=	61.88	26.75
	Distance (in meters)	$\bar{X}$ =	7.83	13.67
		S.D.=	6.85	3.93
Testing Socially	Response Speed (in seconds)	$\bar{X}$ =	.52	.19
		S.D.=	.52	.40
	Orientation (in degrees)	$\bar{X}$ =	22.50	00.00
		S.D.=	24.65	00.00
	Time Moving (in seconds)	$\bar{X}$ =	39.50	82.17
		S.D.=	53.81	39.46
	Distance (in meters)	$\bar{X}$ =	15.00	13.83
		S.D.=	6.07	4.67

Table 25

Summary of Analysis of Variance of Response Speed, Experiment 6

Source	df	SS	MS	F	P
Rearing Condition	1	.1872	.1872	1.06	N.S.
Testing Condition	1	1.4549	1.4549	8.21	.01
R x T	1	.1389	.1389	1.00	N.S.
Error	20	3.5500	.1773		

Final Distance. An F max test for homogeneity of variance was not significant (F max=2.70, P.>.05). No significant differences were found among groups on final distance in analysis of variance (F=2.67, P.>.05).

Discussion

Results, in terms of response speed, indicated that individual testing leads to a stronger nest site attachment response than does social testing regardless of rearing experience. Presence of social companions during testing leads to a decrease in nest returns. Recent data reported by Hogan & Abel (1971) on the effect of social and isolate rearing and testing on response to familiar and unfamiliar environments also indicate decreased response in socially tested birds regardless of how they are reared. The authors interpreted these results to be a result of the inhibition of fear by the presence of social companions. Results of the present experiment are compatible with that view.

No significant rearing effect was found in this experiment. Evans (1970a) also failed to find a rearing difference between socially and individually reared Ring-billed Gull chicks. Hogan & Abel (1971) also did not find a main effect of rearing although they did report that socially reared domestic chicks that were tested individually differed from other groups by changes in preening, calling, pecking, and sleeping. These studies indicate that social versus isolate rearing conditions do not have a significant effect

on preferences for a rearing area.

It may be, however, that the failure to find rearing differences is related to methodological problems, at least in the present study. It may be argued that selecting chicks from natural one-egg clutches introduces a possible genetic or parental behaviour bias since one-egg clutches are rare among Herring Gulls. However, this does not seem likely since no differences were found between individually and socially reared chicks which should be evident if there were genetic or behavioural differences.

A further problem arises because individually reared chicks were not experimentally isolated. Such chicks were reared normally at the nest, where interactions with parents occurred and where social companions could be seen and heard from neighboring nests. Hence, individually reared chicks were deprived only of interaction with siblings. The effect of the absence of siblings during individual rearing may well have been counteracted by the presence of parents and other birds in the nest colony. For this reason, individually reared chicks may not have differed greatly from socially reared chicks that had contact with siblings. Similar circumstances would apply to socially reared chicks tested alone. These chicks were not isolated but tested with siblings remaining at the nest site. Isolate conditions in this experiment, then, may be somewhat confounded by the attempt to test under the natural conditions of the nest site. This may account for the failure to find rearing differences and

the failure to find differences on the other dependent measures. However, the results are, for the same reasons, more representative of what does occur under natural conditions of the nest colony. Furthermore, if parental and conspecific stimulation compensates for sibling stimulation, this would support the original contention that social stimulation is an important factor in nest site attachment.

General Discussion

Stereotyped habitat preferences evident in the behaviour of gulls have been hypothesized to have antecedents in chick behaviour. Thus the prefledging period may be important in establishing habitat bonds (Klopfer & Hailman, 1965). This investigation was designed to test the above hypothesis and to examine the development of nesting habitat recognition and preferences as a function of habitat and social stimuli in neonatal Herring Gull chicks. The initial experiment studied the daily development of nest site preference during the first week post-hatch and weekly development until fledging. The test procedure, which was essentially the same for all experiments, consisted of relocating chicks 20 meters from the nest and recording the chick's movement latency, time moving, initial orientation relative to the nest and final distance from the nest. Several experiments examined the importance of vision and the use of landmarks in nest site recognition. Later experiments studied the role of vegetation characteristics and social stimuli provided

by other chicks in nest site attachment and recognition.

The hypothesis that Herring Gull chicks develop an attachment to the nest site area during the first week post-hatch was supported by Experiment 1. Chicks exhibited an attachment to the nest site which was optimal on Day 6-7. The hypothesis that nest site attachment would wane after the first week post-hatch with the onset of reciprocal recognition of parents and young was also supported by the first experiment. Weekly relocations of chicks until fledging revealed that chicks were increasingly further from the nest with increasing age. The evidence of chick preferences for the nest site support the notion that adult habitat preferences may be established during the prefledging period. Such preferences may account for the return of many birds to their natal colonies for nesting (Beer, 1966; Bongiorno, 1970; LeReche & Sladen, 1970). Long term studies of chicks from hatching to the first nesting season in which chick nest site preferences are correlated with adult preferences for a nesting area would test this possibility.

Early nest site attachment appears to be established through rearing in a particular area. Chicks reared in foster nests from eggs showed the same preferences for the foster area as did normal-reared chicks for their natural nest sites. This data is consistent with other studies (Emlen, 1963; Smith, 1966) in which transfer of gull eggs was affected and the post-hatch behaviour observed. However, the exact mechanism of attachment is speculative. Preferences

for vegetation characteristics similar to those of the rearing area support the suggestion that habitat preferences may be established through environmental imprinting (Thorpe, 1944; 1945; Collias, 1951; Hilden, 1965) in that some form of exposure learning seems to be involved. Studies similar to those done to investigate imprinting to stationary objects (Hess, 1959; Gray, 1960; Bateson, 1966; Bateson & Reese, 1969) using vegetation characteristics as stimuli could be done to assess this possibility. Once established, such nest site preferences could be strengthened by the reinforcing events at the nest site, such as feeding, shelter, protection from predators, social stimulation, etc.

Stimulus properties of the nest site situation which appear to be important in the development of nest site preferences are vegetation topography, and social stimuli provided by other chicks. Chicks were found to discriminate between vegetation types and prefer the vegetation type surrounding the nest. Moreover, although preferences for the nest site, per se, wane with age, preferences for the nest site vegetation apparently remain constant, and chicks restrict their activity to areas of similar vegetation to that of the nest site. These vegetation preferences may be one factor accounting for the stereotypy of habitat preferences noted in gulls. Furthermore, such stable vegetation preferences support the environmental imprinting hypothesis as being the mechanism of attachment. To determine the relation between early vegetation preferences of chicks and

later nest site selection, the vegetation preferences of chicks could be correlated with vegetation characteristics chosen by the same chicks during their first nesting season.

Sibling stimulation was found to be superior to non-sibling stimulation in Experiment 5. Siblings at the nest during testing seemed to enhance nest site attachment, while non-siblings at the nest during testing decreased nest returns. However, testing siblings together as compared to isolate testing decreased nest returns. Hogan & Abel (1971) found similar differences between social and individual testing, and interpreted this difference as being indicative of the inhibition of a fear response by the presence of social companions during testing. It appears, then, that siblings may serve as a motivating stimulus in nest site attachment and may override the nest preference response when present during testing. The latter effect indicates the presence of siblings to be a potent stimulus in preference development.

Cues used in nest site recognition, which seem to be the same for young and adults, include vegetation cues, landmarks and social stimuli. It was demonstrated in Experiment 3 that landmarks are among the cues used by Herring Gull chicks to recognize the nest site. Tinbergen (1953) has reported that adult Herring Gulls use landmarks to locate the nest site. In both cases such landmarks were distinguishable from the background which indicates that "conspicuousness" of stimuli is also important. However,

no conspicuousness differences were found in this study. This failure was most likely due to the lack of differentiation across conspicuous levels, which could be easily corrected by including a stimulus which was not distinguishable from the background vegetation or by levelling an area to ensure that no conspicuous objects were available.

Vegetation type was also found to be an important cue used by Herring Gull chicks in nest site recognition. Correlational data from Experiment 1 showed that chicks were found and relocated in vegetation similar to that of the nest site area. Similar use of vegetation cues has been reported by Bongiorno (1970) for adult Laughing Gulls and by Anderson (1971) for Prairie Chickens. Vegetation height and density may also be used as cues in nest site recognition. Experiment 2 revealed that chicks deprived of vision could successfully relocate in vegetation of the same height and density as that of the collection point. This suggests that auditory and tactile cues may be used in conjunction with visual ones. However, chicks did not relocate in the same vegetation type nor were they able to relocate the nest site. It seems that for these functions vision is heavily relied upon, at least in visually experienced animals. The prepotency of visual stimuli in preference development is also indicated by the fact that visually imprinted stimuli can facilitate the acquisition of an auditory discrimination (Evans, 1972) and can act as reinforcers in imprinting (Bateson & Reese, 1969). Whether visual experience is

necessary to nest site recognition requires further study. It may well be that visually naive animals can use other sensory modalities to successfully locate the nest area. This is quite feasible in view of the response of blindfolded chicks to height and density aspects of vegetation and the fact that gull chicks can recognize siblings (Evans, 1970a) and parents (Beer, 1969) using some auditory stimuli.

Social conditions at the nest serve as cues in nest site recognition. Experiment 5 showed that other chicks at the nest site serve as discriminative stimuli in nest site recognition. Since test chicks could often not see or apparently hear stimulus chicks at the nest, it is likely that parental stimulation is also involved. The reaction of parents to hooded chicks in Experiment 2 shows that parents are aware of changes that occur in the nest situation. Parental vocalization could then influence chick recognition of the nest site, at least when nest conditions are altered, such as when strange chicks are placed at the nest. To assess the role of parental stimulation, marked adults could be observed for vocalization, etc. during testing of their chicks. Also, a control procedure in which parents are not in the vicinity of the nest or are captured during testing, could be compared to testing with parents in the vicinity of testing.

In conclusion, the data support the hypothesis that Herring Gull chicks develop an attachment to the nest site area during the first week after hatching and that the

preference wanes during the following weeks until fledging. Chicks of all ages show a preference for vegetation areas similar to the nest site area. Nest site preferences seem to be ecotypically controlled and it is likely that preferences are established through some form of environmental imprinting and strengthened by the reinforcing events that occur at the nest site. Stimuli controlling nest site preferences include vegetation characteristics and social stimuli. Landmarks, social stimuli provided by siblings, and vegetation characteristics are also among the cues used in nest site recognition. Further study of these factors is required to determine more precisely their role in the development of habitat preferences.

Appendix

Table 26

List of Plant Genera Found on Little Bell Island

Trees	Shrubs	Herbs	Grasses, Sedges and Rushes	Mosses and Lichens
Abies	Alnus	Prenanthes	Festuca	Polytrichum
Larix	Vaccinium	Solidago	Deschampsia	Hypum
	Juniper	Maianthemum	Luzula	Dicranum
	Kalmia	Hieracium	Calamagrostis	Sphagnum
	Ledum	Lysimachia	Carex	Pleurozium
	Chamaedaphne	Achillea	Juncus	Cladonia
	Empetrum	Taraxacum	Alopecurus	Drepanocladus
	Prunus	Fregaria	Eriophorum	Rhytidiadelphus
	Rhodendron	Rumex		Ceratadon
	Rubus	Sanguisorba		Aulacomnium
	Pyrus	Osmunda		Leucobryam
		Epilobium		Peltigera

Table 27

Means and Standard Deviations of Latency and Transformed Time Moving for Chicks Tested during the First Week Post-hatch, Experiment 1

Age Group		Latency (in seconds)	Time Moving (Transformed) (in seconds)
Day 1	$\bar{X}$ =	249.33	.73
	S.D.=	254.07	.67
Day 2	$\bar{X}$ =	205.50	.76
	S.D.=	291.65	.67
Day 3	$\bar{X}$ =	7.50	1.38
	S.D.=	16.41	.48
Day 4	$\bar{X}$ =	3.67	1.63
	S.D.=	8.63	.71
Day 5	$\bar{X}$ =	0.00	1.81
	S.D.=	0.00	.60
Day 6	$\bar{X}$ =	20.83	1.73
	S.D.=	46.41	.52
Day 7	$\bar{X}$ =	2.08	1.86
	S.D.=	5.82	.56

Table 28

Summary of Analysis of Variance of Latency for Chicks tested during the First Week Post-hatch, Experiment 1

Source	df	SS	MS	F	P
Age	6	849080	141513	6.30	.0001
Error	77	.1738E-07	22573.4		

Table 29

Summary of Analysis of Variance of Time Moving (Transformed) for Chicks tested during the First Week Post-hatch, Experiment 1

Source	df	SS	MS	F	P
Age	6	16.75	2.79	7.52	.0001
Error	77	28.58	.37		

Table 30

Number of Chicks Relocated During Weeks 1-5

Chick #	Week 1	Week 2	Week 3	Week 4	Week 5
1	x	x	x	x	x
2	x	x	x	x	-
3	x	-	x	-	x
4	x	x	x	x	x
5	x	x	x	x	x
6	x	x	x	x	x
7	x	x	x	x	-
8	x	x	x	x	x
9	x	x	x	x	-
10	x	-	x	x	x
11	-	x	x	-	x
12	x	x	-	x	-
13	x	-	x	x	x
14	x	x	x	x	x
15	x	x	x	x	x
16	x	-	-	x	x
17	x	x	x	x	-
18	-	x	x	x	x
19	x	x	x	x	x
20	x	-	x	x	-
21	x	-	x	-	x
22	-	x	x	x	-
23	-	x	x	x	-
24	x	x	x	x	x
25	-	x	-	x	x
26	-	x	x	x	x
27	-	-	x	x	x
28	-	x	x	x	-
29	x	-	x	-	x

(cont'd.)

Table 30 (cont'd.)

Chick #	Week 1	Week 2	Week 3	Week 4	Week 5
30	x	x	-	-	x
31	x	x	x	-	-
32	x	x	x	x	x
33	x	-	x	x	x
34	x	x	x	-	-
35	x	x	-	-	x
36	x	-	x	x	-
37	x	-	x	-	x
38	x	-	x	x	x
39	-	-	x	x	x
40	-	-	x	x	x
41	x	x	-	x	-
42	-	x	x	x	-
43	-	x	x	x	x
44	-	x	-	x	x
45	x	x	-	x	-
46	x	-	x	x	-
47	x	-	x	x	x
48	x	x	x	-	x
49	x	x	x	x	x
50	x	-	x	x	-
51	x	x	-	-	x
52	x	x	x	x	x
53	-	x	x	x	x
54	x	x	x	x	-
55	-	-	x	x	x
56	-	x	x	x	-

Table 31

List of Variables in the Correlation Matrix for Daily-tested Chicks

1.	Initial distance from the nest
2.	Location vegetation
3.	Location vegetation height
4.	Location vegetation density
5.	Release vegetation
6.	Release vegetation height
7.	Release vegetation density
8.	Latency
9.	Time moving
10.	Initial orientation
11.	Final distance from the nest
12.	Final vegetation type
13.	Final vegetation height
14.	Final vegetation density
15.	Temperature
16.	Wind speed
17.	Precipitation
18.	Nest site vegetation type
19.	Sky condition

Table 32

Significant Correlation Coefficients and Probability Levels for Chicks Tested during the First Week Post-hatch

Variable	Correlation Coefficient	P
1. Location vegetation height and density	rho= .53	.001
2. Location vegetation height and final vegetation height	r_{xy}= .49	.001
3. Release vegetation height and final vegetation height	r_{xy}= .34	.010
4. Latency and temperature	r_{xy}= .32	.010
5. Final distance and final vegetation type	rho=-.28	.010
6. Temperature and wind speed	r_{xy}= .57	.001
7. Sky condition and temperature	rho= .53	.001
8. Sky condition and location vegetation type	rho= .33	.010
9. Release vegetation height and final vegetation density	rho= .32	.010
10. Release vegetation density and final vegetation density	rho= .32	.010

Table 33

Means and Standard Deviations of Latency, Time Moving (Transformed) and Final Distance from the Nest (Transformed), Experiment 5

	Response Measure		Siblings at Nest	Non-siblings at Nest	No Chicks at Nest
Testing Individually	Latency (in seconds)	$\bar{X}$ =	10.00	53.50	0.00
		S.D.=	24.50	60.67	0.00
	Time Moving (in seconds)	$\bar{X}$ =	1.83	1.54	1.88
		S.D.=	.27	.76	.34
	Distance (in meters)	$\bar{X}$ =	.61	1.13	.92
		S.D.=	.25	.32	.39
Testing Socially	Latency (in seconds)	$\bar{X}$ =	46.67	0.00	5.00
		S.D.=	57.50	0.00	7.75
	Time Moving (in seconds)	$\bar{X}$ =	1.55	1.86	1.98
		S.D.=	.83	.29	.17
	Distance (in meters)	$\bar{X}$ =	.77	1.11	.88
		S.D.=	.28	.21	.27

Table 34

Summary of Analysis of Variance of Latency, Experiment 5

Source	df	SS	MS	F	P
Nest Condition	2	5031.71	2515.86	1.00	N.S.
Test Condition	1	140.03	140.03	1.00	N.S.
N x T	2	12555.00	6277.52	2.03	N.S.
Error	30	92919.70	3097.32		

Table 35

Summary of Analysis of Variance of Final Distance (Transformed), Experiment 5

Source	df	SS	MS	F	P
Nest Condition	2	1.1036	.5518	6.43	.005
Test Condition	1	.0113	.0113	1.00	N.S.
N x T	2	.0779	.0390	1.00	N.S.
Error	30	2.5739	.0858		

Table 36

Means and Standard Deviations of Latency, Experiment 6

	Response Measure		Reared Individually	Reared Socially
Tested Individually	Latency (in seconds)	$\bar{X}$ =	.83	8.33
		S.D.=	2.04	20.41
Tested Socially	Latency (in seconds)	$\bar{X}$ =	106.70	32.50
		S.D.=	241.96	22.30

Table 37

Summary of Analysis of Variance of Latency, Experiment 6

Source	df	SS	MS	F	P
Rearing Condition	1	6666.62	6666.62	1.00	N.S.
Testing Condition	1	25349.90	25349.90	1.71	N.S.
R x T	1	10004.10	10004.10	1.00	N.S.
Error	20	297324.00	14866.20		

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